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Reducing Childhood Pedestrian Injuries: Proceedings of a Multidisciplinary Conference

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July 2002

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Suggested Citation: Schieber RA, Vegega ME (editors). *Reducing Childhood Pedestrian Injuries: Proceedings of a Multidisciplinary Conference*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 2002.

Reducing Childhood Pedestrian Injuries: Proceedings of a Multidisciplinary Conference is a publication of the National Center for Injury Prevention and Control, part of the Centers for Disease Control and Prevention, and the National Highway Traffic Safety Administration, part of the U.S. Department of Transportation.

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Acknowledgments

A special thanks to our sponsors, the National SAFE KIDS™ Campaign and Nestlé USA, who generously assisted us in providing an appropriate setting for the meeting; members of the Steering Committee, who developed the concept for the meeting, selected the presenters, and reviewed drafts of the national action plan; Catherine Kinney, PhD, who facilitated the planning sessions of the Steering Committee as well as the conference; Leslie Teach Robbins and Cecil Threat, who handled meeting logistics; Christine Branche, Sarah Olson, Dan Sosin, David Sleet, Steven Stewart, and Lori Millen, who enabled the conference and helped us publish this document; and Tracey Foster-Butler, Carole Craft, Amy Benson Brown, Leigh Partington, and Sandra Emrich, the editorial staff.

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Preface

...Dedicated to children walking, everywhere

Few news stories are as disturbing as that of a child killed while crossing the street. The photograph below, winner of the 1958 Pulitzer Prize, is still unsettling. Why did it happen? What could have prevented it and why is it still happening, more than forty years later?

It takes only a moment for lives to change. The young child in this photograph, trying to cross a busy street, was struck by a garbage truck as it rounded the corner. We can easily imagine the tremendous imbalance of momentum here—a truck weighing tons, striking a child weighing just pounds. No protective device, no safety gear could have eliminated that disparity.

By design, our society depends heavily on motor vehicle transportation. It sustains our economy and influences our culture profoundly. And yet, every day, each of us is a pedestrian who needs and deserves to share the road safely with motorists.

The right to walk safely seems fundamental, especially for children, yet each year for more than a decade, more than 700 children have died from injuries sustained while walking, more than 500 of these in traffic. Although the fatality rate has declined somewhat during this period, it could be attributable to improvements in pre-hospital and emergency medical care or to a decline in walking as a mode of transportation. As we encourage individuals to get out and walk to combat obesity and other health conditions, we must make sure that they have a safe environment in which to do so.

William Seaman/Minneapolis Star Tribune

Many professionals and advocates have worked for years to reduce child pedestrian deaths in our country. Experts in motor vehicle safety, public health, city planning, school safety, child development, and engineering have wrestled with the problem, each approaching it from that specialty's point of view. But these approaches are limited because the entire solution does not rest within a single specialty. Child pedestrian safety is one of the most complex societal problems we face in injury prevention today.

Effective solutions to the child pedestrian safety problem must be multifaceted and arise from a collaboration among experts from diverse fields. This need originated the Panel to Prevent Pedestrian Injuries, an interdisciplinary conference held in September 1998 to focus on reducing childhood pedestrian injuries in the United States. Three organizations spearheaded the effort and supported the conference—the Centers for Disease Control and Prevention, working to protect the nation's health; the National Highway Traffic Safety Administration, addressing road safety; and the National SAFE KIDS Campaign, advocating for the safety of our children. State-of-the-art position papers were commissioned on key topics in pediatric pedestrian injuries, including epidemiology, education, engineering, sociology, psychology, and research.

These were the basis of discussion at the conference for the nearly 100 experts representing more than 25 professions from four high-income nations (the United States, Canada, United Kingdom, and Australia). Conferees were charged with identifying key barriers to reduce pedestrian injuries and the appropriate next steps to overcome such barriers.

In any such complex endeavor, the meeting planners may be blind to one or more important aspects. In this case, we were focused nearly exclusively on the child, and thus did not adequately consider the key importance of driver attitudes and their behaviors. However, rather than add supplemental information that was not discussed at the meeting, we preferred to maintain its integrity and report only the proceedings that took place during those two days.

Accordingly, this document is the report of those two days of intense discussion about child pedestrian safety. It features the position papers prepared in advance, as well as an expert's formal response at the meeting and the questions and answers that followed. The resulting strategies and actions developed in small group sessions became the *National Strategies for Advancing Child Pedestrian Safety* (Appendix A).

This document is not intended to be a government plan of action, nor to provide recommendations to the government. Rather, these strategies are intended to be used by anyone interested in reducing pedestrian injuries among children, while encouraging them to explore their environment by walking. We urge you to review these deliberations and the consequent strategies, consider them, and implement them. We hope this document will inspire you to dedicate yourself to improving the safety of child pedestrians everywhere.

Richard A. Schieber, MD, MPH
Maria E. Vegega, PhD
June 2002

Executive Summary

Epidemiology of Childhood Pedestrian Injuries

Motor vehicle crashes are associated with one of every five deaths among children 1 to 14 years of age in the United States, and pedestrian injuries account for a third of them. Compared with occupant injuries, pedestrian injuries are more severe; death is five times more likely to occur among those injured. In 1999, 533 child pedestrians were killed, and at least 30,000 children were nonfatally injured in traffic. Another 200 were killed in non-traffic areas, including driveways, sidewalks, and parking lots. Traumatic brain injury accounts for more than half the fatalities.

Dr. Schieber noted that the decline in the child pedestrian death rate over the past several decades may be related more to reduced exposure than to a safer environment or better pedestrian skills. Less walking (a major form of exercise for children) may be partly responsible for the obesity epidemic among American children.

How and where a child is struck greatly depends on the child's gender and age. Boys are more likely than girls to be injured, though this is more likely due to some inherent factor, rather than any difference in exposure to traffic. Overall, children are more likely to be struck in an urban area on a residential street in the late afternoon or early evening. Walking at night or while drunk are risk factors for adult, but not child, pedestrians. Children are at risk when they dart out at midblock, dash across intersections, and alight from buses. Age is a major determinant, since it largely determines their degree of mobility and independence. Accordingly, solutions are also age-dependent. For example, infants (less than one year old) are pedestrians when they are carried in arms or transported in a stroller so their risk is closely related to the caregiver's, the locus of control. Toddlers (ages 1 to 2 years) sustain the highest overall number of pedestrian injuries. Small size and limited traffic experience appear to be factors. They are the most likely group to be injured in a ***non-traffic*** location, especially during driveway backovers. However, fatality statistics that are traffic-based may underreport these events by as much as 50% in this age group, since driveways and parking lots are not classified as traffic areas.

Preschool-age children (ages 3 to 4 years) and younger elementary school children (ages 5 to 9 years) are most often struck as they enter the roadway at midblock, particularly if cars parked along the side of the road shield them from the view of drivers. According to some, they are at higher risk because their knowledge and key perceptual skills concerning traffic are not yet fully developed. As a child's age increases, he or she becomes more mobile, has less supervision, and travels further from home independently. Play may divert focus from traffic. As children mature into preadolescents and young adolescents (ages 10 to 14 years), they acquire more experience in a traffic environment. Even so, a greater proportion of these children are injured on relatively busy streets, further from home.

All age groups share certain risk factors. Their parents often have unrealistic expectations of their street-crossing ability. Drivers pose risks such as inattention, speed, risky driving habits, and the use of alcohol and illegal drugs. Other risk factors include the time when school ends, the proximity of school to home, family income, highest parental educational level achieved, employment status, crowding, ethnicity, family stress, and the child's road environment. Among these, high traffic volume, lower income, and younger age are most strongly related to child pedestrian injury.

There are notable gaps in current surveillance systems used to report pedestrian injuries. In some instances, case ascertainment is incomplete, while in others, information about circumstances of a crash is not collected. Although fatal and non-fatal injuries are reported to the U.S. Department of Transportation by the Fatal Analysis Reporting System and the General Estimates System, respectively, neither dataset captures children killed in non-traffic areas, such as driveways and parking lots, which account for many such injuries among toddlers and preschoolers. On the other hand, although the National Center for Health Statistics does tally the number of children killed in both non-traffic as well as traffic areas, details concerning the crash event are largely absent, and non-fatal injuries are not reported. No surveillance system currently reports enough details of the crash or environment to suggest road engineering improvements at crash sites. Surveillance information that describes the precise location and circumstances of the crash, the volume, complexity, speed or density of traffic at the time, and the crossing distance attempted for each child injured is sorely needed. Such information could substantially influence decisions concerning local road improvements, including traffic control measures.

Sociological Considerations

Dr. Kronenfeld describes a social paradigm in which pedestrian injuries result from social factors interacting together in a dangerous environment. The role of sociology is to define these social risk factors related to the family and peer groups at day care centers and schools. The family is the primary social group through which the child is first introduced to social mores, norms, and conventions. It helps the child develop necessary coping skills, including safety. Several key factors define the family. These include socioeconomic status, a family-based characteristic determined in large part by the parents' income and the highest educational level attained. Family income often determines the neighborhood of residence, type of housing unit, degree of dependence on walking for transportation, existence of fenced-in yards, characteristics of apartment complex play areas and its internal roads, and amount of supervision available to the child during play. Highest level of education achieved by a parent, perhaps at least as important as income, is a primary determinant of lifestyle, which in turn determines many health-related behaviors of the family. Some argue that better-educated families, even more than high-income families, view the occurrence of injuries in a less fatalistic manner and may more readily adopt safety practices. Race/ethnicity also may be important, even if only as a proxy for household income, since White children have lower rates of pedestrian injury than children in minority groups.

Many personal characteristics may have a social, rather than a biologic basis for influencing the risk of pedestrian injury. Rather than being biologically predisposed to injury, boys may have a higher risk because they are given messages that they don't need to be as careful as girls, or because they are supervised less closely. This argument of "nature versus nurture" is important. Issues of social construction are theoretically amenable to educational and social change, whereas biologic differences are immutable. Even so, many social factors, especially income and education level, do not change quickly. Direct approaches to enhance social cohesion in families or to reduce stress are not easily available nor readily tolerated by families. Even attempts to identify high-risk behavior groups may not be fruitful, since only 12% of child pedestrians injured have behavioral problems.

Important solutions, like the injury problem itself, originate in several realms including public health, medicine, education, environmental planning and engineering, and regulation. The complexity of the pedestrian injury problem and the multitude of interactions among social and other factors suggest that prevention measures that emphasize parent education and supervision alone may be insufficient. It is unrealistic to expect a single parent to walk their child to school every day. Instead, improving roadway and neighborhood design, modifying driver behavior, and instituting crossing guards at busy intersections should be considered. Both small- and large-scale changes are needed. The former includes education and modification of school policies; the latter includes redesigning our cities to make them safer for pedestrians. Such major changes will require that many specialists in the fields of safety, education, and public health work together effectively with government and community groups.

In her response, Dr. Gearing added an anthropologist's perspective of the evolutionary development and importance of walking, as well as man's adaptation to the dangers of motorized vehicles. She considered the varying parental expectations of boys and girls, methods of child supervision across socioeconomic status classes, and ways that communities could support busy families whose children are relatively less supervised. In the open discussion that followed, the concept emerged that roadways and neighborhoods do not exclusively belong to adults or drivers, but also to the children who live there. Adopting this approach would shift the focus from the child and parent to the community environment. Instead of protecting children by restricting them, some participants felt that we should remodel our communities to make them more "kid-friendly."

Individual Risk Factors

Drs. Christoffel and Peterson describe individual factors related to the driver and pedestrian. Bio-psychosocial attributes of the child, including gross motor, cognitive, perceptual, emotional, judgmental, and social skills independently affect his or her ability to respond effectively to traffic. Physical attributes, including height, weight, and agility affect the child's ability to see traffic and the driver's ability to see the child. These consequently affect the soundness of a child's strategy for crossing the road. Personality and habitual behavior patterns, particularly impulsivity and aggressiveness may affect risk. The individual's experience in traffic of a certain intensity affects later decision-making in a similar environment.
Four potential interactions of the child pedestrian should be considered, including interaction with the environment, the vehicle, the driver, and the supervisor.

Demographic characteristics of the child are the most consistent and powerful predictors of pedestrian injury. These include age, sex, race/ethnicity, social status, and community of residence. The latter affects pedestrian risk by influencing the degree of neighborhood crowding, availability of parking and traffic controls, and degree of traffic law enforcement. Individual behaviors are also shaped by the child's emotional state at the time, predicated on events of the immediate past (e.g., a recent argument or fight); the anticipated situation in the immediate future; feelings towards peers or any supervisor walking with him or her; and attitude towards the specific traffic situation at hand.

Appropriate or exceptional physical agility appear to increase risk, while physical limitations reduce it. Cognitive developmental level determines the child's ability to focus attention, interpret traffic signs, and remember simple rules. Perceptual development determines the child's ability to locate sounds, judge the speed of an oncoming car, and pay attention to objects in the peripheral visual fields.

Counterintuitively, personality and behavioral traits, including hyperactivity and impulsivity, do not appear to influence pedestrian injury risk, while certain individual factors powerfully affect risk, especially age and developmental level. Other physical, personality and behavioral traits do not substantially increase risk once differences in demographic variables have been taken into account. Emotional instability appears to be a causal factor in some cases. Parents often do not accurately know their child's abilities and vulnerabilities in traffic. The overall style of adult supervision affects the risk of pedestrian injury.

Individual factors of the adult driver include an understanding of normal child development, pertinent physical attributes (especially peripheral vision and response times), personality and habitual behavior patterns, past experience with child pedestrians in traffic, and the ability to pay sufficient attention to children and traffic.

We do not completely understand how well children at each developmental level can learn about traffic safety. While it is sensible and potentially important to tailor safety messages to a child's developmental level, does the resulting training reliably limit injury risk? Should we expect all children of a defined age range to respond in the same way to preventive measures? Could a program broadly aimed at teaching or training an entire population make traffic more risky for some children? Do children with accentuated levels of an individual factor, or the presence of several factors, have the same benefit (or detriment) from a given program? Theoretically, a program could put a child at increased risk during street crossing if he or she becomes less supervised than before. And, if fewer children are injured because they are walking less, what will happen to injury rates if their mode of transportation shifts to favor walking? What is the proper role of the adult in supervising the child pedestrian? What are the key determinants of supervision, what patterns of supervising exist, and how can these be altered to increase pedestrian safety?

Strategies need to be developed to teach adults the normal, expected capabilities and vulnerabilities of children in different demographic groups. Norms for child conduct and adult supervision in different traffic environments need to be prescribed. Countermeasures concerning the environment or better supervision have strong merit. Programs need to target subgroups at greatest risk, to enhance program efficiency and minimize undesirable effects of other groups. Special individual factors (e.g., child's height) need to be considered.

Even so, strategies designed around the "average" child will not address those with special needs. Children with severe vulnerabilities, such as blindness or combined problems of cognitive and physical disabilities, require individual approaches. Parents of children with special needs should learn their children's walking risks and how to reduce them through appropriate supervision and effective management of the child's conduct. This suggests a two-level prevention strategy: one aimed at high-risk groups of normal children, the other aimed at individuals with special needs.

Dr. DiLillo responded by noting why environmental modifications may have limited success in reducing injuries. As a psychologist, he specified certain aspects of adult supervision, including how long and under what circumstances a child may be left without an adult, and how and when parents should teach and train their children concerning road safety. In the discussion that follows, the dispute between supporting environmental versus behavioral change erupts. The value of physical activity in our society was noted. The concept of multiple adults supervising a child, either directly or indirectly, was described. Finally, calling attention to inadequate supervision had a negative effect, and moved caretakers further away from the desired behavior.

Engineering Issues, Barriers, and Recommendations

In Chapter 4, Zegeer, McMahon, and Burden note that many engineering policies and practices have been detrimental to pedestrians. In response to increasing motor vehicle demands, transportation agencies have emphasized designing and building roads. The result is multi-lane roadways that are designed to move heavy volumes of traffic, often at high speeds, between city centers and their suburbs. Such roadways, whether located in commercial or residential areas, have no sidewalks or walkways and little if any shoulder. They often lack medians or refuge islands, and their traffic signals may be spaced one-half mile apart. Once a road has been built without sufficient considerations for pedestrian travel, it may be more difficult to provide for safe foot traffic later. For example, a safety problem created by building an intersection too wide for a child to cross in time cannot necessarily be remedied by painting a crosswalk or posting a pedestrian warning sign afterwards.

Another common engineering practice is to design the intersection of an arterial road so that it can accommodate high traffic volumes and large tractor-trailers making a right or left turn. These large trucks require a wide turning radius to stay upright on the road. Such wide turning radii also allow cars to make right turns at relatively high speeds. However, by their geometry, they greatly increase the distance a pedestrian must cross. To compound the problem, a right-turn-on-red (RTOR) is now allowed in all 50 states, with few local exceptions. Although RTOR motorists are legally required to make a complete stop and then yield to pedestrians and cross-street traffic, drivers may not stop completely. Further, while looking for gaps in traffic coming from their left, they may not see pedestrians crossing in front of them from their right.

The timing of crossing signals may paradoxically increase some risks to pedestrians. Virtually all pedestrian signals in the United States are timed to allow vehicles to turn right or left on a green light during the WALK interval facing the same direction. This allows vehicles to drive across the pedestrian crosswalk at the moment a pedestrian may be crossing.

Children walking to school may encounter roads designed more for cars than pedestrians. Busy arterial streets often lack sidewalks, and the route may require the child to cross a multi-lane, undivided road that lacks adequate traffic control devices or refuge islands, even at sites children must cross when walking to school. Adult crossing guards may be needed yet not available. Bus stops may be improperly located, directing children to wait for the school bus adjacent to a busy street. Parents driving their children to school may create excess traffic congestion at the school drop-off point, or make unsafe traffic maneuvers in that area.

Although children commonly play in their own neighborhoods, many residential neighborhoods have been built strictly with cars in mind. Streets are commonly wide, straight, and provide for parking on both sides. This encourages high speeds on local streets (such as drag races among teenage drivers) and can obstruct a motorist's view of children entering the street from between parked cars.

Other engineering problems that make pedestrian travel less safe include work zones that lack adequate provisions for pedestrians; poorly maintained sidewalks, walkways, and other pedestrian facilities; short signal WALK time or a green phase too brief to allow young children to cross the road; and lack of a shoulder or any other provision for pedestrians along rural roadways.

Several good engineering solutions exist. These include (1) maintaining sidewalks or walkways; (2) employing and training adults to be crossing guards; (3) posting supplemental warning signs; (4) establishing traffic signals or grade-separated crossings where traffic hazards dictate; (5) selecting bus stop locations more carefully; (6) establishing traffic calming measures, such as street-narrowing, speed humps, and partial or full street closures; (7) building streets with tighter turning radii or with new, channelized right-turn slip lanes; (8) increasing the "WALK" time of pedestrian signals to allow enough time for children to cross; (9) establishing more NO TURN ON RED intersections, with signs; (10) providing exclusive pedestrian timing signals that stop traffic in all directions for one interval during each signal cycle, allowing pedestrians to cross; (11) placing bus stops on the far-side of intersections; (12) developing "intelligent" microwave or infrared pedestrian detectors to extend the crossing time for children or other slower-moving pedestrians; (13) reducing the number of lanes on arterial streets while adding sidewalks and bike lanes; (14) converting two-way left-turn lanes into raised medians with left-turn pockets; (15) establishing pedestrian malls; (16) building multi-use paths; (17) removing sight obstructions such as parked cars near intersections; (18) providing safe walking areas in work zones; and (19) improving lighting on neighborhood streets.

Some engineering barriers thwart success. One type of road treatment does not fit all situations. Engineers and planners in one locale may not have used, or even be aware of, successful types of pedestrian facilities elsewhere. They may not understand that a given pedestrian treatment may have varying degrees of effectiveness at different sites. A huge network of roads has already been built in America without sufficient consideration of pedestrian needs, so that a great deal of retrofitting construction needs to take place. Guidelines for engineering and road design to meet pedestrian needs has only recently been created.

Major institutional barriers exist. These include a lack of coordination between local and state engineers and planners, educators, law enforcement officials, and citizens in providing for child pedestrians; inadequate funding allocated or directed toward pedestrian improvements and safety research; and the low priority that elected officials place on walking as a mode of transportation.

Given these engineering barriers, Zegeer et al. in the Executive Summary recommend conducting evaluation research concerning the effectiveness of various types of pedestrian facilities and traffic calming measures; encouraging citizen participation in transportation matters, particularly the selection of pedestrian facilities and improvements; supporting the Partnership for Walkable America, a national coalition of partners concerned with improving pedestrian safety, mobility, and health; aggressively funding and implementing the pedestrian objectives and action plan of the National Bicycling and Walking Study of the Federal Highway Administration by federal, state, and local agencies; training state and local engineers, planners, and their students in building pedestrian-friendly roads with amenities for walkers; and urging metropolitan planning organizations, community traffic safety programs, and state and local transportation agencies to address pedestrian needs.

Elementary schools were often built adjacent to streets with heavy traffic, putting children at potentially greater risk for pedestrian injuries when crossing. These poor designs make retrofitting less effective than at other sites. By comparison, Cynecki noted that other engineering techniques are simpler, such as clarifying the meaning of flashing "WALK" and "DON'T WALK" signals. He also noted the problems of managing cut-through traffic and the high cost of street redesign.

The Role of Elementary and Adult Education

According to Drs. Thomson and Gielen, pedestrian education programs for children have not been very successful. Most such education has taken place in the classroom, with the aim of increasing children's knowledge about traffic and their attitudes toward safety. The assumption is that, by building their knowledge of managing traffic and encouraging appropriate attitudes towards safety, children will be able to generalize what they learn in class to real-life traffic situations. There is no evidence that such programs benefit the roadside behavior of the child. Thomson and Gielen encourage the development of other strategies, both educational and environmental. Since knowledge alone is not sufficient to result in road safety, road safety education programs should also promote the development of skills and the application of these skills in a variety of traffic contexts.

In Scotland, Dr. Thomson has developed road safety education programs that focus on practical training methods at the roadside. Unlike knowledge-based methods that may at best change a child's attitude or ability to correctly answer questions about road safety, practical training methods lead to measurable changes in children's behavior in traffic. They improve judgement and increase a child's ability to cross between parked cars and intersections and helps them time crossings better and plan safer routes while reducing their roadside impulsivity. Such findings contradict the Piaget principle that a young child lacks the intrinsic ability to learn to cross streets safely until he is maturationally "ready." The authors encourage parent participation in such training. Although most safety training and education in the U.S. occurs at school, programs that involve parents in training or reinforcing such lessons may be even more successful in changing behaviors. However, parents may not know what to teach and may overestimate a young child's ability in traffic.

Driver education that addresses pedestrian issues is needed, particularly concerning the importance of yielding the right-of-way to pedestrians. Programs that combine public- and school-based education, improved signage at crosswalks, and police enforcement result in substantially more drivers yielding to pedestrians in targeted crosswalks and fewer pedestrians struck there.

What is still needed? Parents and other caregivers need to better understand the developmental and behavioral characteristics that put young children at increased risk for pedestrian injuries. Before encouraging parents to take a leading role in road safety education, we need to assess their degree of proficiency in this area by asking key questions. What materials and preparation might increase parents' effectiveness as trainers? Are certain traffic skills better taught by professionals? How do parents currently prepare their children to deal with traffic safely? What vulnerabilities do parents perceive their children to have? As with other topics, educational programs in traffic safety must be evaluated.

What should be done next? The classic view that, for maturational reasons, children cannot be expected to cope with anything but the most simple traffic environments and cannot coordinate several variables at once, needs to be reassessed. A more comprehensive taxonomy of the skills and competencies needed to interact safely with traffic should be developed. Skills that are trainable, their optimal training conditions, and target groups should be identified. Training objectives should be established on a scientific basis, considering the elemental components of each model behavior, how an experienced pedestrian might solve such problems, and the underlying skills needed. Approaches that encourage parents to take action, such as those used by the National SAFE KIDS Campaign® and its many local coalitions, should be systematically evaluated. The manner in which parents teach and model behaviors needs to be better understood so that experts can prepare information appropriate for them. Road safety education programs that incorporate traffic simulations need more rigorous evaluation.

Dr. Gielen responded by underscoring the importance of adult education, pointing out that very little is known about parents' understanding of children in traffic and the methods they use to supervise them in traffic. She suggested a broad, multifaceted approach to help adult supervisors function more effectively. The discussion that followed noted a key question: have any existing educational program(s) substantially improved the street-crossing behavior of children? The discussion also noted the relative value of educating drivers.

A Research Agenda

In their chapter concerning individual risk factors, Drs. Christoffel and Peterson note that we do not yet clearly understand the causal sequence linking poverty with pedestrian injuries. Some key associations have been demonstrated, including the association between poverty and lack of adequate play space, residence near high-speed and high-volume roads, and less adult supervision. They feel it is important to better understand how various factors mediate the relationship between poverty and pedestrian injuries. These especially include the roles of supervision and various psychological states of the child.

However, Drs. Rivara and Roberts take a different view concerning research priorities. They feel that we know enough about individual risk factors, but not enough about which interventions actually work. Given this, the limited pedestrian injury prevention funds currently available should be spent on the latter. For example, concerning education and training, they note that proper program evaluation is needed to determine the effectiveness, including cost effectiveness of various educational and skills training programs at different ages. They strongly advocate the use of randomized controlled trials (RCT) to measure such effectiveness, noting that this design is the gold standard for health care research and reduces the likelihood of bias. Using RCT methodology, two groups of people or two groups of existing roadways are created by random assignment. The groups are similar in many ways, and have nearly the same chance of experiencing the outcome of interest (pedestrian injury, in this case). The intervention is provided to only one group, after which the outcome of interest is measured and compared with the baseline. A wide range of environmental initiatives could be evaluated in this manner, and should assess levels of walking, traffic noise, social networking, resident satisfaction and their perceptions of safety. A major challenge is to determine how to fund, coordinate, and conduct such research.

Finally, Zegeer et al. (Executive Summary) in their chapter about engineering, encourage the development of research concerning the effectiveness of various pedestrian facilities and traffic calming in a variety of situations.

Dr. Stevenson noted in his response that the key challenge was to get more children walking again to enhance their health, and while doing so, reduce their likelihood of injury. He also noted that study designs other than the randomized controlled trial may be more practical when evaluating the effectiveness of community programs without compromising validity.

Adopting a New Approach

Although epidemiologic research clearly identifies a decline in child pedestrian deaths in the United States and Great Britain, Drs. Roberts and Rivara note that it may be the result of less walking, rather than safer walking with fewer collisions or better health care of those injured. Health benefits of walking are only one reason, and perhaps not the most important one to reverse this trend. Walking reflects other aspects of societal health, and has direct implications concerning the degree of community coherence, social support, local crime and violence, air and water pollution. Thus, efforts should be made to promote safe walking for reasons other than injury prevention. For example, building a health promotion campaign based on improving the quality of life, community coherence, and urban aesthetics is more compelling to a broad public audience than focusing solely on the value of injury prevention. Designing our cities and neighborhoods to match the needs of pedestrians, not just motorists, is a critically important long-term goal.

Epilogue — Editor's Comment

The point of greatest dispute in these lively discussions was the relative value of education and training versus environmental modification in reducing pedestrian injuries to children. During the conference, spokespersons for each position acknowledged that neither education and training nor environmental modification was a sufficient solution by itself. Those favoring environmental change were concerned about the relatively small impact of educational programs on behavior or outcome. Proponents of education countered that, in the past, education had been provided without skills training, an essential component. Even so, proponents recognized that even the best education and skills training could never teach children to cope with all types of streets and intersections.

Proponents of education and training noted several other benefits. Suppose that a particular child's neighborhood was made relatively pedestrian-friendly and safe. Since those changes could never be accomplished quickly throughout the nation, that child would be at risk if he or she traveled to another neighborhood where such environmental modifications had not been made. To be safe, the child would need to have learned and mastered appropriate road safety skills. A second benefit concerns teaching children to properly use streets and crosswalks. And before they become adults, children at some point need to be taught these skills, because without them, they are not likely to spontaneously understand traffic and know how to proceed safely.

The editors believe that the argument rests on two crucial issues. First, when a motor vehicle and a child collide, the margin of safety for the child is very small. Even though most child pedestrians who are struck are not fatally injured, much worse outcomes could have occurred with only a small change in crash circumstances. Given this premise, an intervention to protect children from pedestrian injury needs to yield a high likelihood of success of protecting the child. Since child pedestrian behavior around traffic is frequently risky, all educational programs or environmental modifications should prevent a collision every time a child walks in traffic. These are indeed stiff measures of effectiveness. They call for evaluation of what works in the field, followed by promotion of those interventions found to succeed by those criterion.

In the end, a combination of educational and environmental measures will be needed, but the specific programs with the right mix to effectively reduce the risk to children may exist only as a prototype. Much work remains to be done to protect child pedestrians, especially in light of the increasing complexity of traffic and roadways, other demands on driver behavior, and the active lives of today's children.

Chapter 1
Epidemiology of Childhood Pedestrian Injuries

Richard A. Schieber, MD, MPH

Motor vehicle crashes are a major cause of death among children in the United States, accounting for about one-fifth of all deaths and 45% of all unintentional injury deaths among children younger than 15 years of age (NCHS 2001). Pedestrian deaths account for 26% of these, totaling 733 children in 1999 (533 of these in traffic), or about 12% of fatalities from all causes of unintentional injury in this age group. Additionally, an estimated 45,000 non-fatal pedestrian injuries occurred in 2000 among children younger than 15 years in traffic and non-traffic areas (CDC 2000). Pedestrian injuries tend to be more severe than occupant injuries: 1.6% of all children struck while walking die, compared with 1.0% of all children injured as occupants of motor vehicles. Among children who die from pedestrian injuries, more than half sustained a serious traumatic brain injury (NCHS 2001). Despite such statistics, pedestrian injury prevention receives substantially less attention than motor vehicle occupant protection from the safety community and the general public.

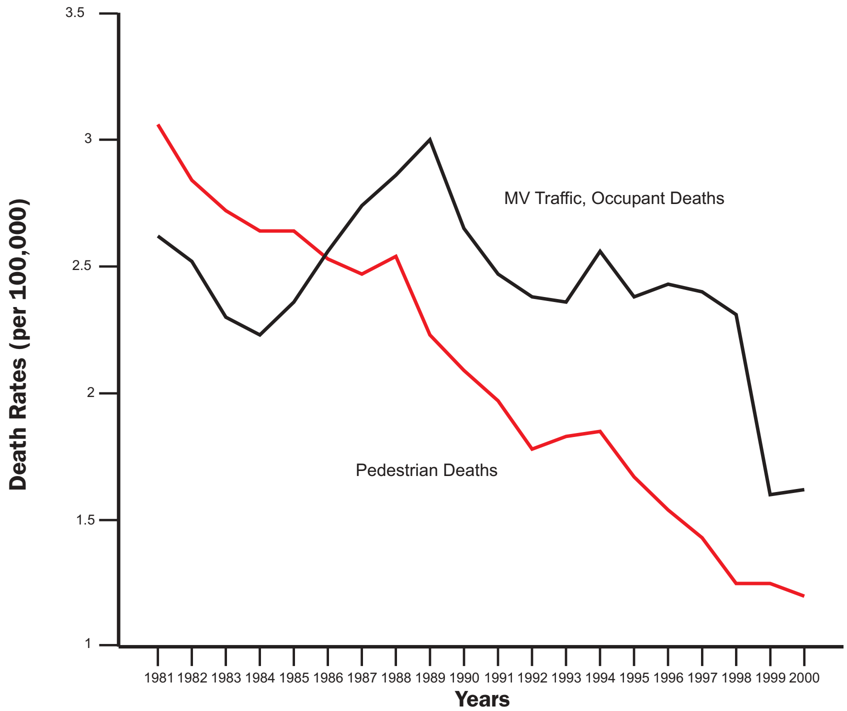
Data Sources Based on Medical Records

Two principal types of pedestrian injury data exist: medical records and police crash reports. These records are maintained by separate government agencies. Public health departments generally compile medical records information, while transportation agencies generally compile police crash report data. Further, fatal injuries and nonfatal injuries are recorded in separate databases, using different criteria for inclusion (e.g., emergency department versus hospital admission) and compiled at different levels of government (national, state, or local).

One of the richest sources of data concerning pedestrian injuries is the United States Vital Statistics Mortality System, which is based on the cause(s) of death indicated on death certificates from all United States residents who die each year. Vital statistics data indicate that, during the past 19 years, pedestrian fatality rates among children younger than 15 years old have declined by 59% in the United States, compared with only 36% for motor vehicle occupant injuries (Figure 1.1). Among infants and children ages 0 to 4 years, pedestrian fatality rates have decreased from 3.3/100,000 in 1981 to 1.5/100,000 in 1999 (NCHS 2001). However, such data cannot determine the cause of this decline. Some have attributed it to advances in pre-hospital and hospital-based trauma care, while others feel it is related to a decline in exposure; in other words, less walking (DiGuiseppi, Roberts, and Li 1997; Ozanne-Smith 1994; Roberts 1993). In 1995, for example, only 8.0% of all personal trips and 10.5% of all trips to school by children ages 5 to 9 years were made on foot (FHWA 1997). Another medical records-based data source is the National Pediatric Trauma Registry of inpatients (Tepas et al. 1989). This unique database records trauma admissions from 60 pediatric trauma centers and children's hospitals in 20 states. The registry has a bias toward the more seriously injured children, since they are more likely to require hospitalization and receive care at a trauma or specialized hospital. It is not nationally representative of all childhood pedestrian injuries, since hospital membership and reporting of cases are voluntary and few general or rural hospitals are included. In 1999, the registry recorded 820 children admitted for pedestrian injuries (personal communication, Carla di Scala, PhD, Boston, MA, September 10, 2001).

A more representative compilation of non-fatal injuries is based on emergency department visits. The National Electronic Injury Surveillance System (NEISS) has, for decades provided ongoing information about patients requiring emergency department care following injuries involving a manufactured product. NEISS was recently revised to include all injuries, including those sustained in traffic or off-road.

Figure 1.1 Pedestian Deaths/Motor Vehicle Traffic, Occupant Deaths United States 1981–2000



Nationally representative data are now available at www.cdc.gov/ncipc/wisqars. Preliminary results for 2000 indicate that an estimated 45,800 children ages 0 to 14 years were treated in hospital emergency departments in the United States, of whom 5,900 (12.9%) were admitted. This is many-fold greater than the number of admissions reported by the National Pediatric Trauma Registry.

Hospital discharge databases provide a third useful source of data. In California, for instance, 1,746 children were hospitalized for pedestrian injuries in 1994, establishing them as the third leading cause of injury hospitalization after falls and poisonings (OSHPD 1996). Hospital charges for inpatient care exceeded $33 million. The New York State Department of Health (1997) reported that, based on its hospital discharge data between 1990 and 1992, more children between ages 1 and 14 years were hospitalized in the state for pedestrian injuries than for motor vehicle occupant injuries.

Data Sources Based on Police Crash Reports

Police crash report-based sources differ from medical records-based sources in several important ways. Medical records-based systems lack detail concerning the causative chain of events leading to the crash and attribution of fault, matters often determined and recorded by the police. On the other hand, police crash reports record only those events that occur in traffic, not off-road. By definition, this excludes injuries sustained on private roads, driveways, sidewalks, and parking lots, each common sites of pedestrian injury among young children. Medical records-based data have no such restrictions on site of occurrence. Thus, data based on police crash reports generally underestimate the true incidence of pedestrian injuries, especially those that are nonfatal (Agran, Castillo, and Winn 1990; Brison, Wicklund, and Mueller 1988; Teanby 1992). Police crash report data estimate that 27,000 children younger than 16 years of age sustain a pedestrian injury each year in this country (NHTSA 2000), a figure six-times smaller than the number estimated by the medical records-based NEISS.

Nevertheless, police crash reports are useful because they describe the location, time of injury, and cause of child pedestrian injuries. From such data, we know that most pedestrian injuries occur in urban areas on residential streets during the late afternoon or early evening hours. Events tend to occur mid-block, at an intersection during a dash across the street, or in association with a bus (Stutts, Hunter, and Pein 1996; Rivara and Barber 1985; Braddock et al. 1991; Kendrick 1993; Stevenson et al. 1992; Preston 1995; Kupferberg-Ben David and Rice 1994; Pitt et al. 1990; von Kries et al. 1998; Fontaine and Gourlet 1997; Baker et al. 1992; IIHS 2000).

General Risk Factors

As discussed in Chapters 2 and 3, epidemiology has been applied successfully to child pedestrian injuries to determine major risk factors for injury (Malek, Guyer, and Lescohier 1990). Three individual-based or family-based risk factors stand out: young age, male gender, and low family income. Additionally, several particularly strong environmental risk factors have been identified, including high traffic volume, high posted speed limit or mean vehicle speed, lack of a protected play area, high degree of curbside parking (which shields children from the driver's view), and the existence of a shared driveway (Wazana et al. 1997).

Gender strongly influences the rate and cause of pedestrian injuries (Rivara and Barber 1985; Braddock et al. 1994; Pitt et al. 1990; Rivara 1990; Children's Safety Network 1991; Christoffel, Donovan et al. 1996). Studies have consistently found boys to have higher pedestrian injury rates than girls. Many have attributed this difference to greater exposure of boys to traffic, an external factor (Stevenson 1991; van der Molen 1981), and to impulsive behavior, an internal factor. Some studies indicate that these gender differences in injury rates are based on intrinsic factors, and not on any difference in exposure to traffic (Routledge, Repetto-Wright, and Howarth 1974a; 1974b; Howarth, Routledge, and Repetto-Wright 1974).

Age is a very strong determinant of pedestrian injury (Figure 1.2). Among children, those between 1 and 4 years of age have the highest pedestrian fatality rate among children, with non-traffic sites (such as driveways and parking lots) accounting for many such events (Table 1.1). Traffic-related death rates among children ages 1 to 4 years are equal to those ages 5 to 9 years. Several studies confirm that young children are at greater risk than other ages for fatal or severe pedestrian injuries (Pitt et al. 1990; Olson et al. 1993). Because national datasets concerning nonfatal injuries have been sparse until recently, trends and generalizations have been based on local data, producing at times conflicting results. For example, some studies indicate higher nonfatal pedestrian injury rates among children ages 1 to 4 years (Winn, Agran, and Castillo 1991), while others indicate that higher rates occur among school-age children (Braddock et al. 1994; Christoffel, Donovan et al. 1996; Martin, Langley, and Coffman 1995; Kraus et al. 1996). Use of the expanded NEISS, upon which Table 1.1 and Figure 1.2 are based, should help clarify the association between age and pedestrian injury risk in the future.

Figure 1.2 Nonfatal Pedestrian Injury Rates by Age
United States — 2000

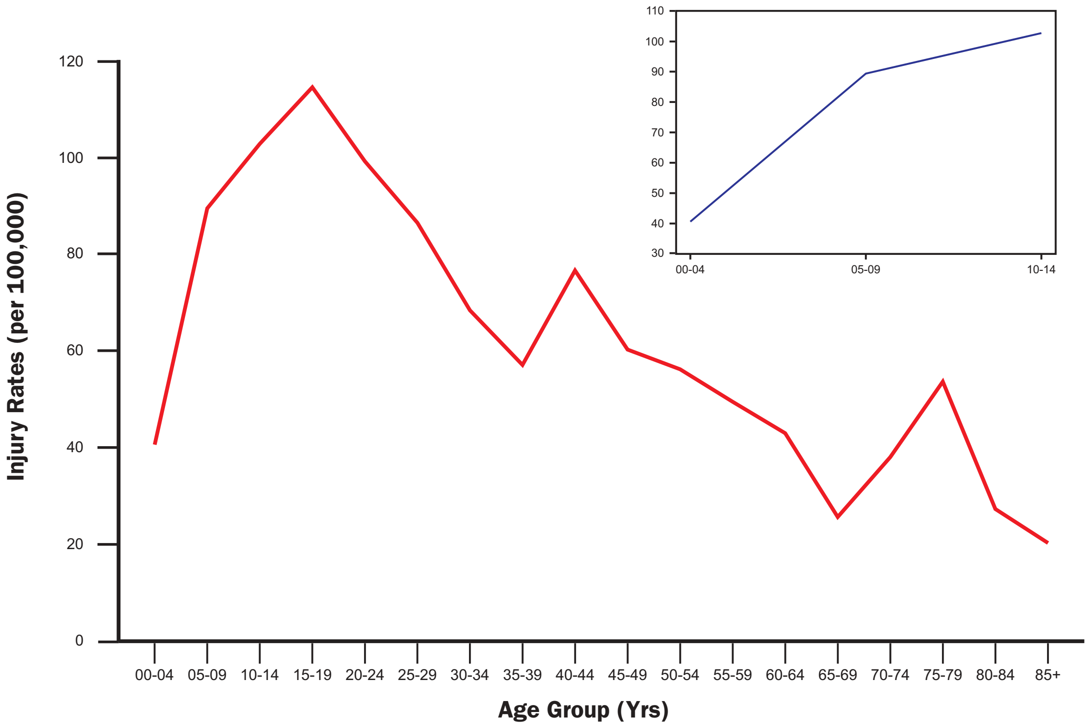


Table 1.1 Death Rates for Pedestrian and Motor Vehicle Occupants Per 100,000 Population, United States — 1999

	0–4 yrs		5–9 yrs		10–14 yrs		Total	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Pedestrian:								
Traffic	177	0.93	192	0.96	164	0.84	533	0.91
Non-traffic	105	0.55	49	0.25	46	0.24	200	0.34
Subtotal	**282**	**1.49**	**241**	**1.21**	**210**	**1.07**	**733**	**1.25**
Motor Vehicle Occupant:								
Traffic	289	1.53	275	1.38	367	1.88	931	1.59

Source: NCHS 2001

Common Pedestrian Injury Scenarios

The nature of common pedestrian injury scenarios varies by age. Infants (by definition, people younger than age one) are pedestrians when they are carried or transported in a stroller or other pedestrian conveyance by a caregiver. The risk of injury to the infant is low, and is directly related to the risk of a vehicle striking the child's caregiver. For example, a caregiver who jaywalks also puts the infant at risk.

Toddlers 1 to 2 years of age sustain the highest overall number of pedestrian injuries and are more likely to be injured off-road than in traffic (Brison, Wucklund, and Mueller 1988; Olson et al. 1993; Winn, Agran, and Castillo 1991; Robinson and Nolan 1997; Roberts, Norton and Jackson 1995). The commonly-cited datasets from the U.S. Department of Transportation do not show a particularly high fatality or injury rate among toddlers because they do not include data from crashes occurring on non-public roads. This results in a systematic underreporting of the true incidence for this age group (NHTSA 2000; Agran, Castillo, and Winn 1990; Brison, Wicklund, and Mueller 1988). In fact, about half the pedestrian deaths of those ages 1 and 2 years occur in non-traffic events, most commonly when they are struck by a vehicle backing out of a driveway. Many involve toddlers who, unseen, follow a parent out of the house and sit or stand behind a vehicle on the driveway, where they may not be visible to the driver, particularly behind a van or pickup truck (Agran, Castillo, and Winn 1990). This cause of serious and fatal crush injuries is unique to young children.

Most pedestrian injuries among preschool children ages 3 to 4 years occur when a child enters the roadway at mid-block from between two parked cars on a residential street, the so-called "dart-out" (Rivara 1990; Winn, Agran, and Castillo 1991). They are frequently playing near their homes, alone or with other children, and are unsupervised by an adult (Thackray and Duker 1983**.** Children ages 3 and 4 years are too young to play in or near traffic, whether alone or with other young children. When engrossed in play, they are unlikely to remember any warnings to stay out of the street. They focus on only one task at a time and have little ability to inhibit impulses. Their ability to perform the tasks necessary to deal successfully with traffic is inconsistent and unreliable. For example, a preschool child is unlikely to effectively dodge a moving vehicle in his or her path. According to some, they lack sufficient cognitive awareness or knowledge of road safety (e.g., understanding road signs and comprehending traffic terms) to reliably cross the road by themselves (Schieber and Thompson 1996; Vinjé 1981; Ampofo-Boateng and Thomson 1991; Sandels 1970).

Numerous studies have indicated that school-age children between ages 5 and 9 years are at greatest risk during childhood (Rivara 1990; Children's Safety Network 1991; Stevenson and Sleet 1997). As with pre-school children, the most common cause of pedestrian injury is the midblock dart-out (Stutts, Hunter, and Pein 1996; Kupferberg-Ben David and Rice 1994; Rivara 1990; Agran, Winn, and Anderson 1994; Kraus et al. 1996; Schofer et al. 1995). During the late afternoon and early evening, they have the greatest exposure to traffic, and are at greatest risk. Compared with younger children, school-age children are more mobile, usually play with others, ride bicycles and other pedestrian conveyances, and travel further from home. When playing, they likely do not focus on crossing streets safely. Perceptual skills needed for correct pedestrian behavior (e.g., depth perception or assessment of speed of oncoming vehicles) and the ability to assess hazards correctly are still developing. They do not often know or understand traffic patterns, street signs, or rules of the road. School-age children cannot be relied on to cross most streets safely, yet parents and drivers often expect such an ability and unwittingly put them at risk (Schieber and Thompson 1996; Sandels 1970; Vinjé 1981; Dunne, Asher, and Rivara 1992; Rivara, Bergman, and Drake 1989).

Between ages 10 and 14 years, children are at lowest risk for pedestrian traffic-related injury during youth (NCHS 2001; Rivara 1990). Their judgment and skills in dealing with traffic are markedly better than younger children, and they have more experience with traffic. However, they are more mobile, walk further distances from home, and often do not have direct adult supervision. Accordingly, they tend to be injured on busier streets located further from home (Agran, Winn, and Anderson 1994; Preston 1994).

Recommendations

Pedestrian injury surveillance systems have notable gaps in case ascertainment and the environmental circumstances of a crash. No surveillance system currently reports enough details of the crash or environment to suggest road engineering improvements at specific local crash sites. Surveillance information is sorely needed that describes for each child injured the precise location and circumstances of the crash, including vehicle speed and relative traffic volume. Such information could substantially influence decisions concerning local road improvements, education, regulations, and other methods of intervention.

Chapter 2
Sociological Considerations

Jennie Jacobs Kronenfeld, PhD

Background

Sociology is the systematic study of the development, structure, interaction, and collective behavior of organized groups of human beings. It focuses on the group, unlike psychology, which focuses on the individual. Sociology research uses databases in which the individual, rather than the group, is the record and unit of analysis. A framework, known as a construct, is developed to describe the possible impact of the social structure on the person.

Several important factors define a social group, especially, the social class (including socioeconomic status, or SES), ethnicity, and race of its individuals. In relating social class and health, some researchers have hypothesized that belonging to a lower social class group increases vulnerability to illness (Syme and Berkman 1976). Health researchers often equate social class with SES, which includes more than social class but is a useful simplification. SES correlates with disease occurrence, health risk factors, and use of health care services. SES is often discussed as an individual characteristic, measured using one or more composite scales popular in the United States and Great Britain that are based on the characteristics of the individual. However, SES is actually a family, rather than an individual characteristic, since the level (or standing) of SES determinants in a given family are set by its adults, not by its children.

Three components are common to most SES scales—income, education, and occupation. Family income is useful because it is relatively simple to measure and because it often determines the neighborhood and type of housing in which a child lives and the amount of supervision that occurs during play. In turn, the type of housing may determine whether children play in traffic, on an internal road within an apartment complex, or in a sequestered area. The neighborhood and type of housing may also determine safety features of the environment, such as protective fences near busy roads. Income may also determine the mode of transportation used for traveling to and from school and the degree of supervision involved. Education has historically been considered a paramount component of social status for health studies. Individual behaviors that relate to health have been viewed as a function of lifestyle, of which education is a primary determinant (Lefcowitz 1973). Some argue that education may be more important than income in developing one's view of the preventability of injuries. Because better-educated families view injuries with less fatalism, they may be more eager to use safety devices or adopt practices that could enhance their child's safety (Sheehy 1982).

Racial and ethnic classification is a subject of great debate within the research community. Some public health researchers have argued that the use of race as a classification measure is generally inappropriate for most public health and medical research (Cooper and David 1986). For example, classification of multiethnic people by even their primary ethnic group may be difficult. Most social scientists, as well as many health researchers now argue that race/ethnicity should be viewed as a single variable, one that is socially constructed. Traditional scales have tightly linked SES to race or ethnicity, making it difficult to disentangle these two variables from income or education. This is particularly true in safety research concerning the United States, Australia, and New Zealand. And yet, some have recently considered both gender and race to be variables that are socially constructed, not biologically determined, if not a mixture of both. Certainly some variables previously considered biologic may in fact be social in origin, or both biologic and social. For example, the role of women in the family has varied through history, as influenced by class and race, even though the gender group itself of course has not changed. Thus, gender is likely influenced by both biologic and social factors. And yet, knowing a person's gender tells us very little about their health or social status (Krieger and Fee 1994a, 1994b). Health status may vary between men and women in American society because of different role expectations, role burdens related to work and family, and imbalances in power, equality and control (Rodin and Ickovics 1990). These psychosocial factors go far beyond genetics, even though they have genetic origins. As a social reality, gender often transforms and interacts with biology. In much the same way, race and ethnicity are considered by some sociologists to be social categories, rather than biologic categories (Krieger and Fee 1994a; Cooper and David 1986). For example, a psychosocial factor may affect boys more than girls because the two genders engage, qualitatively if not quantitatively, in different social roles. These subtle issues need to be recognized when analyzing racial and gender differences in injury patterns. King and Palmissano (1992), however detected a 2.5-fold increase in hospitalization rates for serious, nonfatal pedestrian injuries among Black children (compared with White children), after adjusting for differences in age, gender, and payment class as a possible surrogate measure of SES.

Sociological Considerations in Childhood Pedestrian Injury Prevention

In childhood injury prevention, the family is often a useful construct because it is the single most significant socializing institution in our society and one to which children are ubiquitously exposed. It is the primary social group through which a child is first introduced to social mores, norms and conventions. The family helps the child develop skills necessary to safely cope in society. However, constructs other than the family may be useful. For example, since the child is socialized by other, broader social groups, their influence should be considered. In this regard, the child's peer group is important. Today, exposure to peer groups may occur at a very early age, such as in day care centers and later in elementary school.

For family members, age is consistently noted to be an important risk factor for pedestrian injuries, with children younger than nine years of age at greatest risk of death (Stevenson and Sleet 1997; Lapidus et al. 1991; CDC 2002). Some argue that more injuries befall children in this age group because of developmental factors, such as lesser ability to scan effectively or judge distance (Schieber and Thompson 1996). However, social factors must also be considered. For example, most parents would not permit their preschool children to walk beyond their sight without supervision, yet readily send their young elementary school children to school by themselves. Parents regularly overestimate their young child's ability in traffic (Dunne, Asher, and Rivara 1992). This sudden loss of adult supervision may increase the likelihood of injury, particularly those caused by errors of judgment or by the poor visibility of a small child. At the same time, the child is rather suddenly exposed to complex traffic, often with little or no preparation, experience, or supervision. Support for this view comes from a case-control study that concluded that the age-specific distribution of pedestrian injuries is related in part to exposure to traffic (Stevenson, Jamorzik, and Burton 1996). Another study noted sites where children of different ages were injured, which may indirectly indicate the complexity of traffic to which they are commonly exposed. The median age of children injured on driveways was 2 years; on parking lots, 4 years; at midblock crossings, 6 years; and at intersections, 10 years (Agran, Winn, and Anderson 1994). Thus, as children become older, they may be exposed to more intense levels of traffic that exceed their developmental capabilities, for longer periods, and without parental supervision.

Gender is another key variable that defines one's social group and affects risk, either directly or indirectly. The behavior of American children is frequently categorized by gender, and social constructs are developed using the "lenses of gender" (Bem 1993). Researchers commonly debate whether gender-based differences in injury rates are biologically based or determined by the social construct. For example, are boys more impulsive by biologic nature, or do we teach boys that they do not need to be as careful as girls, and perhaps even supervise them less closely than girls? Assuming that social construct is important, the more that injury rates are influenced by gender, the more likely it is (in theory) that their reduction might be amenable to improvements in education and other key aspects of social change. Many epidemiologic studies about childhood injury prevention find that boys and girls have different rates of injury. Boys are over-represented in pedestrian injuries, with fatality rates about 1.5 times greater than girls (NCHS 2001; Rivara 1990; Stevenson and Sleet 1997; Routledge, Repetto-Wright, and Howarth 1996). Some researchers argue that this difference is due to greater exposure by boys to road traffic (Jonah and Engel 1983). Some studies have found that more boys are described as "outdoor children" (Newson and Newson 1976) and more likely to use streets as recreational sites. However, boys are not more likely than girls to be exposed to traffic during purposeful trips such as running errands (Chapman, Wade, and Foot 1980; Sheehy 1982). In fact, some studies have found girls to have equal or even greater exposures to traffic than boys (Roberts, Norton, and Taua 1996; Roberts, Keall, and Frith 1994). Another reason commonly cited for the higher injury rates among boys is their intrinsic behavioral differences, particularly inattention and impulsivity (Routledge, Repetto-Wright, and Howarth 1996). Alternatively, it could be due to the generally more advanced development of girls at any specific age up to adolescence. As evidence, the difference in injury rates between genders decreases with developmental maturation as children approach adolescence and adulthood (Grayson1980; Sheehy 1982).

Low SES is associated with higher childhood pedestrian injury rates (Stevenson and Sleet 1997; Roberts et al. 1991; Baker et al. 1992; Dougherty, Pless, and Wilkins 1990; Durkin et al. 1994; Bagley 1992). The childhood pedestrian injury rate was up to six times greater for those living in neighborhoods of the lowest income quintile, compared with those from the highest quintile (Roberts et al. 1992; Dougherty, Pless, and Wilkins 1990). Some of the difference in risk may also be related to pedestrian exposure and number of family vehicles owned (Roberts, Norton and Taua 1996).

Race may be a marker for, rather than a cause of, pedestrian injury. In the United States, White children are injured at lower rates than other races (Stevenson and Sleet 1997; Agran et al. 1996a). In New Zealand, the rate of injury is lower among children from a European background (Roberts, Norton, and Jackson 1995). In the United States, a strong interaction exists between social class and race/ethnicity, and between type of neighborhood and SES. An alternative (untested) explanation for the higher rates of injury among minority children is that they are simply poorer. The traffic patterns in low-income neighborhoods may be less safe because drivers there may violate speed laws more frequently and because fewer traffic controls such as stop signs, speed bumps, and crossing guards may exist (Stevenson, Jamrozik, and Spittle 1995). Low-income parents may be less able to advocate successfully at the local level for crossing guards or placement of speed bumps in neighborhoods to discourage speeding. Therefore, minority children may have higher pedestrian injury rates because they are poorer, and poorer children in turn may be exposed to a less safe environment, in part because of the parents' social status and lack of political influence.

Just as neighborhood, SES, and race/ethnicity interact, so do variables related to family and degree of supervision. Studies indicate that accompaniment by adults on the school-to-home journey reduces pedestrian risks for children (Routledge, Repetto-Wright, and Howarth 1996; Rao, Hawkins, and Guyer 1997). This is associated with ethnic group and number of family vehicles owned, which itself is linked to income and, at least in part, determines how parents arrange activities and their children's return home from school. For example, children whose parents owned an automobile and a house crossed an average of only 3.9 streets per day, compared with 5.4 streets crossed per day for children whose parents owned neither (Rao, Hawkins, and Guyer 1997).

Barriers and Recommendations

Unfortunately, many sociological factors related to child pedestrian injuries are not readily amenable to policy change. Although as children grow older they will naturally move into a lower risk category, no social policy can modify their age and gender, nor is any likely to improve the family's overall SES in a short time period. Furthermore, educational programs and policy interventions designed to improve social cohesion in families or reduce family stress are not readily available (Christoffel, Donovan et al. 1996). Prevention initiatives designed to change basic characteristics of families and individuals are unlikely to be effective or easily tolerated (Stevenson and Sleet 1997; Langley, Silva, and Williams 1987).

School-based educational programs could potentially reduce childhood pedestrian injury rates (see Chapter 5). Policy changes that improve the design of housing, neighborhoods, and transportation should be considered, but only as long-range options. Healthcare providers are an important source of information for parents, yet their advice on this matter consists of increasing supervision (in particular, to avoid driveway backovers and street dart-outs) and training older children to plan safer routes with less traffic or fewer intersections (Agran, Winn, and Anderson 1994). Multiple approaches are needed.

A number of studies abroad have demonstrated that adult accompaniment on the school to home journey is associated with a reduced risk of injury. But in American society, how realistic is that solution? When both parents need to work for financial security or fulfillment, or in single-parent households (presently 28% of all U.S. family households), walking a child to and from school is not very realistic (Roberts 1995a; Roberts 1994; U.S. Census Bureau 2000). Other countermeasures need to be considered, especially education, driver training, and traffic engineering. Modifying neighborhoods to create additional pedestrian walkways to schools that are safe would help. Greater use of traffic calming measures in key residential neighborhoods may be helpful (see Chapter 4). Although this is most commonly considered when designing new communities, such changes need to be implemented in existing communities, particularly in less affluent neighborhoods where children walk more in general. Perhaps school districts should reconsider what minimum distance a person needs to live from the school in order to qualify for bus transportation. Also, districts might post more crossing guards, particularly at busy intersections. These are more manageable solutions, both simpler and more socially acceptable than proposing that all children be accompanied to school by adults.

Because these solutions have cost implications, parents and other taxpayers may need to be convinced of their usefulness. There are social implications of these changes as well. Changing the road infrastructure requires agreement and prioritization by local traffic engineers, as well as support by neighbors living on those streets. These steps will be greatly assisted by support from neighborhood organizations.

Conclusion

Childhood pedestrian safety is a complex issue. The linkages with sociological variables lead to complex solutions, not simpler ones. Some of the most important sociological and demographic factors are either basic characteristics of the child or of the social structure, and are therefore very difficult to change. More modest solutions require additional education and modifications of school policies and neighborhood design. Such small changes are more realistic in the immediate future. Larger changes will require safety researchers, public health personnel, community groups, and other professionals interested in protecting children to mount a well-coordinated, long-term campaign.

Response
Sociological Aspects

Jean Gearing, PhD, MPH

As an anthropologist, I want to put the pedestrian injury problem into the perspective of the two million year evolution of our species. We are unique among primates because we adopted bipedal locomotion or walking. All of our other evolutionary advances, notably, opposable thumbs, large brains, and language, followed from our having adopted walking as the method of locomotion. The health, emotional, and psychological benefits derived from walking as exercise are based on our built-in evolutionary preferences. The chronic health problems brought about by a sedentary lifestyle stem from the violation of our evolutionary heritage of walking.

With the invention of the automobile, very different challenges arose for our species. Pedestrian injuries are a reflection, just one result, of the brief time we have had to adapt to the sudden danger injected into our environment by the invention of motorized vehicles. Whereas ancient man coped with new threats through the slow process of biological adaptation, modern man principally adapts by changing his culture or otherwise developing solutions rapidly. We now change the environment, rather than let the environment change us.

How do gender, family, and social class interact, and how can we develop effective strategies to overcome these difficulties? Much responsibility for childhood safety lies in the child's adult caretakers, and parenting styles are class-specific. For example, different classes see gender in a different light and this influences the likelihood of occurrence of childhood pedestrian injuries. Traditionally, boys are encouraged to engage in sports and outdoor activities, to fight when challenged by peers, and to roam about their neighborhoods with little supervision. It is the willingness to take such risks and master them that defines a "man" in most societies. Encouraging boys to be cautious opposed other messages of their cultural programming which taught them to "become a man" rather than a sissy.

Parents' expectations that boys will be more physically active than girls may be based on actual differences in their physical activity levels, although before puberty, there is little difference in their true physical capabilities. Parents tend to project differences in coordination and physical strength between the genders at a young age, although true gender disparities do not emerge until middle adolescence. Adult expectations of boy's behavior, particularly risk-taking and stifling or crying or complaining following an injury, are grounded in culture, not biology. Ironically, the greater impulsivity of boys puts them at greater risk of injury when they do precisely those things we encourage. In the past, girls have traditionally stayed closer to home and were not encouraged to take up sports. Working and lower-class girls tended to be drafted by mothers to help out at home, giving them even less time to walk outdoors.

Most safety programs have been developed by the well-educated, middle class and do not take into account differences in parenting styles of different SES groups that affect supervision, rule-making, and their enforcement. Among lower and working classes, rules are laid down by parents, usually unilaterally by the head of the household, and enforced by physical punishment. Children are expected to speak when spoken to and to know their place. In contrast, middle- and upper-class parents who are better-educated tend to have more democratic disciplinary methods, explaining to their children why they make certain rules, rather than relying on force.

What safety messages should we be giving families? Often, parents simply need accurate information about the relative physical ability of children at different developmental stages. Gender-specific prevention messages are needed to explicitly tell parents that protecting their sons from injury will not turn them into sissies. Educational safety messages need to consider differences in parenting styles. Parents need to learn more about normal childhood development, such as that provided by child abuse advocacy programs for at-home education of parents. Such established programs might also incorporate helpful information about unintentional injury prevention. Distinct programs for children should be developed to consider different genders and SES classes.

Many policy recommendations concerning adult supervision are unrealistic. Some programs encourage parents to watch their children more carefully, yet do not recognize when and why this might not be feasible. Many parents hold two or even three jobs. A parent coming home from a job that is physically demanding may be exhausted. Female heads of household return home to face a so-called "second shift" consisting of family and household chores that are not compensated. Such parents depend on their older children, sometimes only 9 or 10 years old, to be the primary supervisors of their younger children, without considering this neglectful. Telling parents who have compelling economic pressures that they must increase their degree of supervision will not necessarily (or even likely) change their behavior. Meanwhile, unsupervised children home alone after school ("latch-key kids") could face greater injury risk.

Lower-income neighborhoods need additional and better quality playgrounds and parks where it is safe to play. While conducting a local safety project in lower- and working-class communities, we noted that children tend to play in their front yards and the street, particularly in the evening after their parent returns home from work. The local playgrounds there did not have room or equipment suitable for older elementary school children, even though the facilities were quite suitable for very young children and toddlers, as well as for older adolescents and adult men. To prevent pedestrian injuries among elementary school children, we must work with city planners and engineers, not just to build more sidewalks, but also to build neighborhood parks and playgrounds. These must then be sufficiently safe from crime so that parents will allow their children to walk there and play alone. Meanwhile, to help latch-key kids, injury prevention specialists can join with those conducting after-school programs to supervise children in useful activities, rather than sending them home alone. This becomes even more important as welfare reform returns more parents to the workplace. Alternatively, though probably less popular with school administrators, the school day could be lengthened to match school dismissal with the end of the parent's workday.

These are all opportunities for change that make sense for the social domain of the child. We can make the changes we need if we begin by changing our priorities to put children's health, safety, and well-being first. Our long-term survival as a species has always depended on protecting our young and we must take these responsibilities seriously.

Open Discussion
Sociological Aspects

I. Roberts: Some children see the road as an extension of their living space. We need to entertain the idea that pedestrian injuries are not a developmental weakness of children, but rather, a developmental weakness of adults. Why do adults think that roadways are solely their domain and not that of children? This is being addressed in Britain. In a housing study in Leeds, a community closed the road because it was a national holiday. They liked that so much they wanted to close it again, and eventually, closed it permanently. Now they have a "home zone," which is a street redesigned for children and pedestrians where traffic engineers built playground equipment in the middle of the street (Children's Play Council 1998). In such home zones, children are encouraged to play in the street. Another movement in Britain is "Road Peace," an organization of mothers who have lost children on the road. They think that everything can change and we need to think that, too.

B. Wilkinson: Let's fix the problems, not adapt to them. Let's not look at keeping children in schools longer. Instead, let's look at creating safe neighborhoods and communities where kids can walk home and go outside on their own. We need to be careful that we don't define the problem just in terms of our own discipline or the tools of our own profession. It may be that the solution is going to come from some place other than what we have under our control. Let's stay open to that.

J. Fegan: The percent of trips taken by foot has decreased. One theme that we will keep coming back to is that we need much better data on exposure and on the amount of walking that is actually occurring. We need to think about whether we want to encourage children to walk more, particularly by substituting walking for some motor vehicle trips.

T. Miller: I was surprised to see that neither the anthropologist nor the sociologist talked about why we are seeing pedestrians in general, and walking in particular, decline. A lot of those changes came about from the rise in mandated, forced busing. Now the courts are saying it is time to end that. We may see an increase in children walking to school again, especially because some neighborhoods were originally designed so you could walk to school. Related to that, we've seen a decline in children walking because of fear of crime. Is violence against a child walking to school considered a cause of child pedestrian injury? That element needs to be included when considering the creation of a safe pedestrian environment.

Unidentified: Another factor here is socioeconomic status. It is easier to complete projects in lower SES areas and more difficult in affluent areas.

Unidentified: We need exposure-corrected data to properly evaluate interventions. We also need to realize that encouraging more walking relates to transportation goals for all modes. This entails decreasing the number of people riding in cars. Therefore, a simultaneous goal should be to decrease occupant travel in cars.

Unidentified: We need to evaluate busing mileage limits and how the school starting times interact with rush-hour traffic.

Chapter 3
Individual Risk Factors

Katherine Kaufer Christoffel, MD, MPH[2]
Lizette Peterson, PhD

Most factors influencing the risk of pedestrian injury for children are based on family considerations or community norms, not on individuals. Nevertheless, individual risk factors should be considered when planning prevention programs (Christoffel, Donovan et al. 1996). The potential importance of individual traits has been extensively studied in the hope of finding a factor that could be modified. Considerations of the individual are important because they largely define the child's risk of injury, even while walking with others. The causal sequence of a child walking to a particular site at a particular time where he or she is injured is at least partly unique to that child. Various prevention strategies that might successfully interrupt a specific causal sequence include approaches related to the individual.

Child Risk Factors

Several studies have shown that certain individual traits of a child (Table 3.1) are associated with increased risk of injury (Christoffel, Donovan et al. 1996; Pless, Peckham, and Power 1989; Agran et al. 1998). Together, these factors identify subpopulations of children who merit prevention programs. The most powerful risk factors among these are demographic: age, race, gender, social status, and community of residence, discussed in previous chapters. For the most part, these factors are not subject to change. Some interrelated factors that affect the risk of pedestrian injury include biopsychosocial development, physical attributes, personality, and habitual behavior patterns. Key individual risk factors for childhood pedestrian injury are listed on Page 23.

Biopsychosocial Development. Biopsychosocial development helps explain the marked variation in pedestrian injury rates and circumstances that occur with age (Schieber and Thompson 1996). The specific developmental attributes that influence the risk of injury have not all been defined, but surely include gross motor, cognitive, perceptual, emotional, judgmental, and social factors. It is clear that pedestrian skills develop during elementary school age. For example, elementary school children younger than eight years old, unlike older children, did not devise routes of travel near their school that were safe (Ampofo-Boateng et al. 1993). Vinjé (1981) articulated the complex manner in which various developmental factors influence a child's ability to respond to traffic challenges and skills training. He suggested that preoperational children (2 to 7 years old) lacked the ability to make precise judgments about traffic. This would indicate that behavioral training for children this age should be limiting and rigid, and include directives to: (1) stay away from the curb unless preparing to cross; (2) look in both directions to check for vehicles when crossing; (3) cross only when no vehicles are coming; and (4) stop and look at oncoming drivers, making eye contact when possible. It is not yet known whether such training would reliably reduce pedestrian crash rates. In fact, theoretically, a young child might be put at increased risk if allowed to cross unsupervised at this age, despite such training. It may be necessary to finely tailor pedestrian safety messages to a child's specific developmental level within several age brackets.

Physical Development. Several studies indicate the strong association between physical or gross motor development and pedestrian injury. Physical attributes, such as height, weight, and agility, affect a child's ability to see traffic and be seen by motorists (Schofer et al. 1995). Physical attributes also determine a child's walking speed (Sleight 1972) and the strategies available to help negotiate crossings. Physical limitations appear to reduce risk (Pless, Verreault and Tenina 1989). Although counterintuitive, children

[2]Topic presented at conference by the lead author of each Chapter.

Table 3.1 Individual Risk Factors for Child Pedestrian Injury
(Asterisks indicate topics for which substantial knowledge exists)

Demographic*
- Age
- Race/Ethnicity
- Gender
- Social Status
- Community of Residence

Biopsychosocial Development
- Gross Motor/Physical*
- Cognitive*
- Perceptual*
- Emotional
- Judgment
- Social

Physical Attributes
- Height*
- Weight
- Sensory Abilities
- Medical Problems
- Agility

Personality and Habitual Behavior
- Outgoing *v.* Shy
- Leader *v.* Follower
- Impulsive *v.* Passive
- Hyperactive *v.* Quiet
- Behavior in Traffic

Experience in Traffic
- General
- Specific Traffic Circumstances

Emotional State
- Social Situational
- Social Relationships (Peers, Supervisor)
- Physical Site

Adult Supervision*
- By Whom
- Content, including level of vigilance, proximity, and control
- Supervisor's awareness of child's developmental abilities
- Differences in supervision based on traffic site

between five and eight years old who have high self-estimates of physical agility appear to have increased, rather than decreased, risk of injury (Christoffel, Donovan et al. 1996). Plumert (1995) found that children in early elementary school overestimated their own abilities more often and to a greater extent than did adults completing the same psychomotor task. Six-year-old children with higher levels of overestimation sustained higher levels of medically-attended injury. Although the mechanism is not clear, children with high physical agility may overestimate their ability to move sufficiently, rapidly, and effectively on foot to avoid traffic, thus taking more chances in traffic than less agile children. When observed, children take longer to cross streets than they think. Also, more agile children may be allowed greater freedom in traffic, ignoring the fact that superior physical skill is not necessarily accompanied by superior judgment in traffic.

Cognitive Development. Several important cognitive skills are age-related. Young children may have difficulty focusing their attention on traffic, preferring to attend to other matters (Schieber and Thompson 1996). Even children who can recite the rule "Don't run out into the street" may dart out at times. Also, young children often misinterpret traffic signs. For example, a yellow sign with a child running may mean to a child that it is safe to cross the street, when in fact it is a warning to motorists that children may be present. Children's memory for even simple rules of traffic is unreliable. Grayson (1975a, 1975b) found that 39% of children observed did not even look into the street before crossing, even though they knew the rule to look before crossing.

Perceptual Development. Children's ability to locate sounds is poorer than that of adults (Sandels 1970), as is their judgment of the speed of an oncoming car (Vinjé 1981). Furthermore, children tend to detect objects in their peripheral vision less well and more slowly than adults (Lakowski and Aspinall 1969; David et al. 1986).

Behavioral Traits. Although widely expected to influence pedestrian injury risk, rigorous analyses have generally not found that behavioral traits have a profound influence. Across many studies, behavioral factors are not consistently or substantially associated with the risk of pedestrian injury, particularly when compared with the influence of demographic or environmental factors (Pless, Verreault, and Tenina 1989; Christoffel, Donovan et al. 1996).

Personality factors and habitual behavior patterns such as impulsivity and aggressiveness could affect a child's risk in traffic. Among a group of British children ages 8 to 11, boys who "never sat still" were 67% more likely to sustain a pedestrian or bicycling injury than other boys (Pless, Peckham, and Power 1989). However, aggressiveness and behavioral disturbances were not significantly associated with increased risk (Pless, Verreault, and Tenina 1989). Overall, the possible association between various psychological states and pedestrian injury occurrence has not received much attention by researchers, except perhaps in the context of reconstructing the sequence of events that led to a pedestrian injury (Christoffel and Schofer 1996).

Emotional Development. The emotional state of a child at a specific moment may shape his or her behavior by affecting the degree of attention to traffic or willingness to take risks. Relevant emotional domains for children include their feelings towards the situation or place that they are leaving or approaching (e.g., school or home); feelings about peers who accompany them, which may provoke a typical behavior such as daring or boasting; feelings towards a supervisor (whether or not present), which may affect the child's willingness to comply with traffic rules; and positive or negative attitudes toward the specific traffic situation at hand, based on knowledge, emotions, or both.

Supervision. Supervision is a key element of pedestrian injury prevention. Only 19% of children younger than 15 years old who were struck as pedestrians during a midblock dart-out were accompanied by an adult (Agran, Winn, and Anderson 1994). Poorly-supervised children were 2.6 times more likely to sustain a pedestrian injury than children who were adequately supervised (Pless, Verreault, Tenina 1989). And yet, the degree of supervision necessary to assure child safety in all circumstances is presently unknown. Parents appear to overestimate their children's abilities and vulnerabilities in traffic, at least until about 9 or 10 years of age (Dunne, Asher, and Rivara 1992). The permissible duration of supervision for various activities, including playing in the vicinity of traffic, varies among well-meaning adults. In one study, the opinions of mothers, child protective services workers, and medical personnel differed concerning the duration of time an infant or child could safely be left unsupervised in the home, yard, neighborhood, or near the street (Peterson, Ewigman, and Kivlahan 1993). Even specifying the relative degree of hazard in each of these sites did not result in unanimity of opinion. For example, adults reported that they would allow children between ages six and eight years to be unsupervised as long as 30 minutes when playing near a street with little traffic. Risk is partly determined by their style of adult supervision, characterized by degree of proximity and physical contact, and the number of other children they supervise simultaneously. However, most research studies have not objectively or systematically defined supervision well enough to make inferences useful for planning injury prevention programs. A notable exception is the more precise taxonomy for supervision developed by Wills and others (1997a, 1997b), who defined supervision as "the presence of a familiar person 12 years or older and at least three years older than the child being supervised who could reach the child within five seconds." They derived 10 different types of supervision by considering the presence of a designated supervisor, whether the supervisor was a teen or an adult, proximity of the supervisor to the child, and the presence of peers. Using this definition, they found that only 36% of children injured as pedestrians had been supervised. Supervision patterns were related to such psychosocial variables as family size and cohesiveness. This study was supported by Bass and others (1995) in Cape Town, South Africa, who found that only 24% of injured children had been supervised at the time of injury. Additionally, they noted a strong relationship between childhood pedestrian injuries and playing or running errands during daylight in the late afternoon.

Other Risk Factors. A child's general experience in traffic and specific experiences with a particular circumstance or site also affect his or her capacity to make decisions such as ability to detect space between vehicles in oncoming traffic.

Adult Risk Factors

A similar group of individual factors could be listed concerning the adult driver or supervisor. These include the supervisor's knowledge of child development and how it might affect behavior and consequent risk in traffic, and the supervisor's understanding of the unique developmental capabilities and vulnerabilities of a specific child in various settings (Dunne, Asher, and Rivara 1992). Physical attributes of the driver (e.g., height, ponderosity, agility, perceptual acuity) contribute to traffic habits they develop and their moment-to-moment behaviors. Supervisors' beliefs are formed from their own experiences and local cultural norms. These in turn influence their expectations of children's behavior in traffic and their own strategies for supervision. The supervisor's personal experience with traffic, including knowledge and perceptions of risk in traffic (whether general or at a specific site) affect their interaction with children. The ability of drivers and supervisors to focus on children walking in traffic depends on other matters competing for their attention. Such distractions include noisy child passengers or concomitant use of a cellular telephone; intensity of roadway traffic; and their own emotional and physical state related to work, financial and logistical situations at home, other children, childcare arrangements, depression, fatigue, or intoxication. Finally, a child's pedestrian behavior is modeled after adults, especially parents, including where and how suddenly the adult enters the roadway, and how quickly that adult crosses the street.

Interaction of Child and Adult Risk Factors

How might individual child and adult factors interact? Four interactions with the pedestrian should be considered: the pedestrian-environment, pedestrian-vehicle, pedestrian-driver, and pedestrian-supervisor. Of these, the first two concern interactions with the adult and child.

- The pedestrian-driver interaction is affected by the physical environment and the degree to which the driver can see the child on foot (largely influenced by the child's physical attributes), the child's ability to anticipate the driver's behavior, and the driver's ability to predict the child's path based on his experience and perceptual acuity (Howarth 1995; David et al. 1986; Harrell 1994). Visibility is also affected by the degree of ambient light. Because daylight-saving time by law always begins before Halloween, children are at particular risk at the time of this celebration. Along with an increased exposure to traffic, they also have a four-fold increase in the number of pedestrian deaths that evening compared with any other evening of the year (Ferguson et al. 1995; CDC 1997).

- The pedestrian-supervisor interaction is affected by the child's family/social environment and the perception of his or her abilities in traffic by relevant adults. These influence the adult's decisions concerning when, where, and how to best supervise each child (Wills et al. 1997a, 1997b).

- The pedestrian-environment relationship is affected by how, where, and with what frequency a child walks in the community. Important factors include a child's likelihood of encountering vehicles (especially fast or large ones), supervision while walking, the number of peers crossing with him or her, and the degree to which he or she understands traffic, including the roadway structure, vehicle travel patterns, and signals (Mueller et al. 1990).
- The pedestrian-vehicle interaction is affected by how well a child can see, judge, and avoid an oncoming vehicle. The child pedestrian's ability to see the vehicle is determined by his or her height and perceptual acuity, while the ability to judge vehicle speed and traffic gap size is determined by experience, developmental level, and perceptual acuity. The ability to avoid an oncoming vehicle is determined by experience, judgment, and agility. The driver's likely response to a darting pedestrian is to swerve, while the child's likely response is to quickly retrace his or her path.

Based on the individual factors of children and adults, a useful taxonomy has been developed (Schofer et al. 1995). It classifies pedestrian injury events according to two variables: suddenness of appearance and speed of motion. To the driver, a child may appear suddenly in the road (i.e., hidden until the last moment from the driver's view) if he or she darts out between parked vehicles, is short or hidden by shrubbery or other roadside or roadway obstruction, or if the driver's attention had been distracted from the road just before the collision. A child may move quickly into traffic (generally without scanning for traffic threats in advance) if they are on a mission, hurrying to get somewhere, or playing a game that periodically spills out into the street. In the classic midblock dart-out, the child simultaneously appears suddenly and moves quickly.

The Role of Individual Risk Factors in Planning Prevention Strategies

No individual risk factor decisively predicts child pedestrian injury, therefore it is difficult to justify developing a prevention strategy based on individual risk factors for an entire population. Even if such a strategy were to be developed, its implementation would require prior identification of risk factors for each individual, a difficult and expensive task and one with potentially unintended negative psychosocial consequences. As with many other types of injuries, child pedestrian injury prevention strategies are more likely to succeed if they focus on commonly occurring adverse environmental factors, elements of supervision in or near the street by all caregivers, and are developmentally appropriate.

Key individual attributes of high-risk groups (e.g., age) should be considered when planning interventions. Environmental strategies should be aimed at the majority of those at risk, such as children whose height falls between the 10th and 90th percentiles for the high-risk age groups. Effective educational approaches are needed to teach adults about the usual capabilities and vulnerabilities of at-risk children. Norms for child conduct and supervision should be prescribed for various common traffic environments, such as supervising all preschool-age children when they cross a street.

Strategies designed to fit the most common child attributes are likely to reduce danger for every child at risk, including the most vulnerable, such as the blind, or those with combined cognitive and physical disabilities. The numbers of such children are too sparse to affect population risk. However, because the specific abilities of each child to negotiate traffic on foot may be delayed compared to his or her peers, and because the ability to walk is of such keen importance, an individual approach must be taken. Parents and other caretakers of vulnerable children need to learn what specific pedestrian risks they have as a result of their disability, and what special supervisory measures are needed.

Thus, what we know about individual pedestrian injury risk factors among children leads to a two-tier prevention strategy. The first tier should be aimed at broad subpopulations of children at risk while essentially ignoring the possibility of variable risk within these groups. The second tier should be aimed at specially vulnerable individuals using techniques modified from the first tier, but suited to each individual's needs. One might characterize these as public health and clinical prevention strategies. This kind of two-tiered approach has been adopted in other areas of child health promotion, such as the practice (until the mid-1990s) of administering live polio vaccine to the general public but inactivated polio vaccine to a select few who have a deficient immune system (Chipman 1995).

The Role of Individual Risk Factors in Planning Research

Even though considering individual risk factors may not be of paramount concern in developing population-based control measures to limit pedestrian injury risk, several such issues do deserve study, as noted below.

- Do unbalanced levels of physical and cognitive skill development contribute substantially to risk? If so, it would be desirable to help caregivers identify such persons.
- Some individual risk factors might have differing degrees of influence in different traffic environments. For example, how might risk change if the number of children walking were to suddenly increase? The number of pedestrians increased abruptly in 1993 in Amsterdam (Simons 1993), and could happen in selected environments if urban planning and/or transportation patterns change quickly and substantially. In such circumstances, the relative importance of individual risk factors should be reevaluated.
- Research is needed to design individual risk prevention approaches for those children at excess risk because of low or discordant functional developmental levels. Such research might first compare the pedestrian exposure, behavior, and supervision among younger children versus older special-needs children.
- Research is needed to evaluate the effect of community prevention approaches on injury occurrence to determine whether they reduce or even increase risk among those with special needs.
- Individual prevention strategies for children with heightened risk for pedestrian injuries should be evaluated rigorously. For example, comparisons should be made between impulsive children who receive added protective efforts with those who do not. Multi-center studies would probably be required to enroll enough of these children to achieve sample sizes adequate for multivariable hypothesis testing.
- Considering how psychological states and traffic experience contribute to pedestrian injury risk might help tailor supervision for children at times when they are less emotionally stable than normal or are unfamiliar with a traffic site or pattern.
- Much more information is needed concerning the role of adult supervision in child pedestrian injury risk, especially the chief determinants of supervision patterns and how these can be altered to increase safety. This area of research is more feasible than in the past because a useful taxonomy is now available (Wills et al. 1997b).
- Exploring behavioral mechanisms involved in pedestrian injury, including the antecedents and perceived consequences of specific behaviors, is vital. For example, children may not use a pedestrian overpass because of the delay and physical effort involved, or because they

and their peers have successfully and repeatedly run across the street without being injured. Analysis of factors influencing how children assess risk versus benefit of varying methods of crossing the street would be useful.

- Finally, all individual-based pedestrian injury research should adhere to two design standards. First, traffic exposure should be measured rigorously as a covariate. Second, pedestrian injuries and issues should be separated from those of bicycling, since their demographic and other risk factors are different.

Summary

Certain individual risk factors, such as those related to developmental level, contribute substantially to the risk of pedestrian injury. However, in the aggregate, personality and behavioral traits, including hyperactivity and impulsivity (Davidson 1987) do not appear to contribute substantially to risk among the entire child pedestrian population (particularly when analyses control for demographic variables), although they may be important in special instances. Except perhaps for height, physical attributes such as physical development and perceptual difficulties contribute very slightly to overall risk. Height needs to be taken into account when designing strategies to enhance pedestrian visibility and mutual awareness among pedestrians and drivers. Little is known about the contribution of a child's experience and psychological state to pedestrian injury risk, although emotional instability sometimes surfaces as a causal factor in individual occurrences.

Prevention efforts should be focused on issues of demography, the environment and its potential adaptations, and supervision. Separate attention should be paid to the needs of children with cognitive and/or physical disabilities that can put them at greater risk. A research program should emphasize a better understanding of the role of supervision, various psychological states of the child, and the needs of disabled children. Exposure should be measured in all such studies.

Response
Individual Risk Factors

David DiLillo, PhD

I would like to address two main points. First, how well can we expect environmental changes to work to reduce unintentional injuries? And second, what do we know about how parents supervise their children to prevent injury?

Environmental alterations can often provide an effective means of protecting children from pedestrian injuries, so it makes sense to focus our initial attempts there. After all, it is much easier to construct a physical barrier or make some other type of environmental modification than it is to change people's behavior. Unfortunately, environmental modifications have several limitations. First, given the range of circumstances of pedestrian injury events, no set of physical barriers or environmental changes will prevent all such occurrences. Second, our society greatly values economic and aesthetic matters, sometimes to the detriment of safety. For example, a hedge may be planted by the side of a road to enhance local beauty even though it obstructs a driver's view of the side of the road and endangers child pedestrians trying to cross there. Finally, environment-oriented solutions may not be implemented prudently, and may not consider human behavioral or social issues. For example, a large park with a playground and basketball court was built near the center of Columbia, Missouri across the street from a public housing development. Anticipating that these residents would be the principal users of the park, a pedestrian overpass was constructed. Of the four child pedestrians in that town struck by cars during the past several years, three were injured at this site. Inquiries later established that children considered the number of stairs required to climb this overpass to be excessive (even though they were going to a playground), so they preferred to dart across the road. Their cumulative success in crossing the road in that manner reduced their fear of being struck by a vehicle, further reducing the likelihood of using the overpass. Such behavioral and social mechanisms of environmental interventions need to be considered.

How do parents actually supervise their children in high-risk situations? What are the proper elements and degrees of supervision needed to prevent injuries at each developmental age? Parents are widely regarded as the key socialization agents for their children, assuming primary responsibility for their children's physical safety. However, Garbarino (1988) notes that inadequate supervision by parents is responsible for a sizeable proportion of children's unintentional injuries. And yet, we know very little about what constitutes appropriate parental supervision of children in various situations (including street crossings) across a range of risks.

The most basic question regarding supervision is how long and under what circumstances children at each age can be safe when left without any adult supervision. Finding nothing in the literature to address this question, Peterson and colleagues asked physicians, Department of Family Service (DFS) workers, and mothers to give their opinion about the elements of appropriate parental supervision (Peterson, Ewigman, and Kivlahan 1993). Each group was asked how many minutes they would leave children of various ages alone in various locations, including the roadway, kitchen, and garage. Although it was expected that greater consensus would occur among DFS workers and physicians because they had access to injury literature and possessed some expertise in safety issues, no such consensus was found. For example, children younger than seven years probably do not have the necessary skills to walk alone across a street under any circumstances. Even so, several respondents reported that they would allow a four-year-old child to cross a street without adult supervision in sparse traffic. Others considered it acceptable for a six-year-old child to do so in medium levels of traffic. With professionals apparently overestimating children's abilities to perform risky tasks, it is hard to imagine how parents might answer questions about simpler tasks, such as letting a young child cross a street with a parent but without holding his or her hand, or letting a child walk ahead of a parent in a crosswalk.

How and when should parents teach and train children about safety and injury prevention? Some studies suggest that the most common ways parents try to influence their children's safety behavior are through education and establishing rules, rather than by using discipline or the threat of negative consequences, even though the latter two are more effective in motivating behavior change in children. Using vignettes that provided common excuses children give for not wearing a bicycle helmet, we studied techniques parents would use to promote helmet use. Mothers of 2nd and 8th graders read these vignettes with their children, and then reacted to them. Initially, regardless of the excuse made, mothers tended to invoke a rule or begin a safety discussion with their child. They did not, however, name an unpleasant consequence for non-use, a tactic known to induce behavior change of children more effectively. If a child would continue to refuse to wear a helmet, the likelihood of consequences increased. However, in the end, a sizable minority of parents ultimately would have allowed their child to ride without wearing a helmet. These findings suggest that caregivers are reluctant to implement some of the most effective means known to encourage children to abide by safety rules.

To sum up, prevention specialists need to explore all possible avenues to ensure the safety of child pedestrians. To do so, we need to go beyond environmental barriers and consider other social and behavioral factors that underlie children's injuries. Caregiver supervision is one such factor. Some important questions still need to be addressed. What kind of caregiver interventions are most effective in preventing injuries among children at each level of cognitive, social, and affective development? What parenting skills, abilities, and habits are best matched with each type of preventive intervention? When are children most receptive to learning safety interventions? When does the best teaching moment occur; before the child gets injured, or immediately after, but before he or she forgets the injury event? Finally, it would be useful to develop a standardized instrument to assess parental supervision in risky situations. Such an instrument could be used to teach parents what level of supervision is required for different ages, activities, and circumstances.

Open Discussion
Individual Risk Factors

H. Spivak: We talk about interventions that help change attitudes, but there isnít always a direct link between changing an attitude and changing a behavior. Strategies need to deal with factors, attitudes and behaviors. They may not always follow the sequence we expect.

S. Flocks: I think you may be writing off the potential value of engineering solutions by picking out the worst examples. Pedestrian bridges like the one you described are now seen as mistakes by the most knowledgeable and progressive engineers, who would now favor precisely the interventions you suggested. Also, expecting a high level of supervision is unrealistic in a society where most women work and where we have a lot of single parent families.

Unidentified: In discussing supervision, we seem to keep coming back to the sexist model that the supervisor has to be the mother. These days, I don't think that is correct. Also, supervision should not be the sole mode of protecting children in traffic, although it should be one component of a comprehensive, community-wide intervention strategy. Children of certain ages in certain situations need to be supervised. We need to think more broadly about solutions.

Unidentified: Environmental engineering solutions should be our first line of defense against pedestrian injuries. They are the most cost-effective and successful. However, they do have limita tions and, unfortunately, many outmoded methods of barrier intervention still exist, such as the pedestrian overpass you cited. For this reason, it is important to replace such misguided engineering efforts. It is also important to supplement effective environmental interventions with those targeting social and behavioral factors associated with injury.

M. Stevenson: I think that child pedestrian injuries are a matter of mass exposure. If most children were walking, they would all be exposed to road hazards, and the problem would likely be perceived as an environmental one; conducting community environmental interven tions would be favored over identifying and targeting selected at-risk children.

K. Christoffel: Children are at risk for pedestrian injury simply because they are children. They need to be protected from pedestrian injury in all the ways we have been discussing. In addition, some children are at higher risk than others due to geography or social class, and we need to focus on them. Finally, some children are at an astronomically higher risk in traffic because they have a rare circumstance or condition, such as the child with cerebral palsy or poor vision. Population-based approaches will probably not suffice for such children with special health-care needs. Preventive care, like health insurance, should be universal, but a few will need special assistance.

B.Wilkinson: We need to consider adapting better to children, rather than changing them to our standards. That population has a rapid, constant turnover, which makes it difficult to deliver a program to them. We need to pay a lot more attention to the motor vehicle operator. Our studies have shown that one out of 10,000 potential accidents to 5-year-old boys is being avoided, as is one out of 100,000 potential crashes to 10-year-olds. These studies show that children, rather than drivers, took avoidance action when the vehicle was more than 20 yards away. Thus, drivers appear to be abdicating this responsibility to the child, who is expected to do whatever is necessary to avoid the crash. That is something we have to factor in when we target specific interventions.

M. Fenton: The ability to explore is important to a child's cognitive development. As a health promoter, I believe that kids need a lot of physical activity in their daily life. This creates a potential conflict between the natural desire to keep a child safe in a controlled setting versus allowing him or her to spend time in some unsupervised activity crucial to development.

K. Christoffel: I don't think supervision is a restraint, just as I don't see discipline as a restraint. Discipline is helping the child learn the things a child needs to learn. It's not sitting on the kid, it's facilitating their learning behavior. Similarly, supervision means the adult is exercising responsibility to make sure children are safe to do the exploring they need to do. Those requirements vary by the age of the child, the situation, the particular attributes of the traffic environment, and the child's needs. If we say that supervision entails a loss of freedom, there is a clash. If we see supervision and discipline as factors that need to work together to the child's benefit, there is no contradiction.

D. DiLillo: We recently studied parents' attitudes about the way children explore their environment, and found that most parents endorsed letting their child explore, even at the risk of getting a little hurt sometimes. We are not sure if the parents' attitudes correlate with their actual behavior, but if so, that issue needs to be addressed.

I. Roberts: Road Peace is a group of British mothers of children who died in pedestrian injuries. Each of these mothers has had to deal with the feeling that the child's death was her own fault. If the public health focus is on supervision as one of the most important countermeasures, when a child dies, will the grieving parents then be left with that horrible thought? How can we recommend better supervision without inducing enormous guilt?

K. Christoffel: It's not just the mother's job to supervise her child. It's the job of every adult in the community to make sure children are safe. That involves a collective approach to supervision, which means if I'm working near your kid, I'll take care of your kid's needs. So, if a child gets hit by a car, the community has not supervised that child well. In isolated situations, it may be that a particular supervisor will have failed, but the presumption that this huge societal burden is uniquely the responsibility of the mother every moment of her day is crazy.

B. Alberson: Another way to frame that idea is as other layers of protection.

Chapter 4
Engineering Issues, Barriers, and Recommendations

Charles V. Zegeer, MS; Patrick J. McMahon, MRP, and Dan Burden

Too many of our nation's streets and highways are built to accommodate heavy motor vehicle demand at moderate to high speeds, with little or no regard for pedestrian needs. Trying to provide safe pedestrian crossings as an afterthought may then require enormous costs (e.g., building a pedestrian overpass) or simply not be feasible. To help non-engineering professionals understand how environmental changes can reduce pedestrian injuries among children, we first describe present road engineering practices in the United States. The next section notes the principal engineering barriers to safer roads. We conclude with seven recommendations and five case studies.

Current Roadway Management Practices that Threaten Child Pedestrians

Roadways are managed predominantly by state and local transportation agencies. Although agencies do provide for pedestrian facilities for travel on some roads, many management and engineering policies and practices have been detrimental to pedestrians, particularly children. Motor vehicle capacity has too often been the paramount priority. Agencies historically have placed a heavy emphasis on designing and building streets and highways to keep pace with motor vehicle demand. Designing for increasing highway capacity and improved level of service[3] or driver comfort has resulted in multi-lane roadways that move heavy volumes of motor vehicles, often at high speeds between central cities and their suburbs. Because transportation systems have focused primarily on one mode of transportation: privately occupied vehicles, walking in some city centers has been largely abandoned because pedestrian needs were not adequately considered when solving mounting traffic problems.

A carefully controlled study by Agran et al. (1996b) in Orange County, CA indicated that certain environmental factors were closely related to the risk of injury. In particular, streets where more than 50% of the curb was occupied by parked vehicles were a high-risk situation. Increasing vehicular speed was associated with a marked increase in risk. Unexpectedly, the authors found that increasing traffic volume was associated with a progressively lower risk. This study suggested that measures should be undertaken to reduce the amount of street parking (thereby increasing visibility) and reduce vehicular speed.

Arterial roads are often unfriendly to pedestrians. Multi-lane roadways in commercial and residential areas often lack sidewalks, walkways, and suitable shoulders. Some local and state departments of transportation resist building sidewalks and walkways, even on routes to schools and parks. Often, school-age children must cross multi-lane roads that lack a median or refuge island, or where traffic signals are spaced so many blocks apart that children must cross at non-signalized intersections or even mid-block between them. Traffic on these multi-lane roads often moves at 40 to 50 miles per hour, with the gap distance between vehicles too small for young children (who normally have difficulty assessing speed and adequacy of gaps) to cross safely. As an afterthought, a pedestrian warning sign or a painted crosswalk may be installed in a vain attempt to solve a severe safety problem brought about by automobile-dominant planning.

Intersections can be deadly to children. In recent years, intersections on arterial streets have often been designed and built to accommodate high traffic volumes and allow large combination vehicles to make right and left turns more efficiently, i.e., at higher speeds. When planning an intersection, the

[3]A glossary of commonly-used terms is provided in Appendix A.

engineer often assigns priority to the turning vehicle. Since moving traffic along is of paramount importance, a wide turning radius is designed because it allows vehicles to make right turns at relatively high speeds. However, such intersection designs have undesirable consequences for the pedestrian. In particular, they increase the crossing distance for pedestrians and require them to contend with vehicles turning right on green at high speeds across their path. The problem is compounded by the use of right-turn-on-red (RTOR), now permitted in all 50 states (except in New York City), unless signed otherwise. Although RTOR motorists are required by law to make a complete stop and yield to pedestrians and cross-street traffic, drivers looking for gaps in traffic to their left may not see pedestrians crossing in front of them from their right (Zegeer and Cynecki 1985). This too places young child pedestrians at particularly great risk.

WALK signals at intersections do not guarantee safe passage. Most pedestrian signals in the United States are timed to allow vehicles to turn right or left on a green light during the WALK interval, a procedure known as "standard" or "concurrent" timing. At intersections with traffic signals, those with standard-timed pedestrian signals had no safety benefits compared with those that had no pedestrian signals (Zegeer, Opiela, and Cynecki 1982). Other engineering factors also influence safety in crosswalks. Drivers in trucks sometimes cannot see children in crosswalks. Also, the trailer of a right-turning tractor or semi-trailer may easily run over the curb, striking an unsuspecting child pedestrian waiting to cross.

Often, the location of neighborhood schools can be a threat to children's safety. Decades ago, neighborhood schools were designed with convenient access so that children could walk or bicycle safely along local streets to school. Now, elementary schools are frequently placed in relatively high-traffic areas along busy arterials, which often lack sidewalks, or require the child to cross multi-lane, undivided roads that lack adequate traffic control devices such as raised medians or stoplights. To make matters worse, some school districts do not provide adult crossing guards where needed. School bus stop sites, if placed without careful consideration of children's safety, may require children to wait for the bus next to a busy, high-speed roadway rather than on a local street. Parents driving their children to school increase local traffic congestion, and their erratic driving at that time is potentially risky for pedestrians.

Many neighborhood streets are unsafe for children walking or crossing. Often, no sidewalks exist, since neighborhoods were built strictly with vehicles in mind. Streets are often straight and wide, which encourages speeding and drag-racing by teen drivers. Vehicles may park on both sides, making it more difficult for motorists to see children crossing mid-block. The risk of mid-block dart-out collisions on such streets is high.

Other management and engineering decisions contribute to the risk of child pedestrian injury. Work zones often lack adequate provisions for pedestrians. Sidewalks, walkways, and other pedestrian facilities are often maintained poorly. Rural roads often lack shoulders or any other pedestrian facilities.

Current Engineering Solutions

1. Crosswalks, Signs, and Signals

Crosswalk improvements include better location and identification; better signage; addition of adult crossing guards at school crossings; improved timing of traffic and pedestrian signals; and better detection of pedestrians in the crosswalk.

Crosswalks are appropriately located at signalized intersections and school crossings, among other places. Marking them with paint helps identify them to pedestrians, indicating where they should cross, and thereby making their actions more predictable for motorists. Nevertheless, children in crosswalks have been injured because they erroneously assume that all vehicles will automatically yield to them. Besides locating them at signalized intersections, marked crosswalks may be effective on selected low-speed narrow streets, particularly in conjunction with signs, flashing lights, raised medians, refuge islands, curb extensions, and other measures (Van Houten and Malenfant 1992). Various types of crosswalk markings may enhance their identification and make them more visible to motorists. Regulatory school speed limit signs ("25 mph when flashing") may also be desirable in some situations. However, these may not be sufficient, particularly for helping children cross multi-lane roads or streets with moderate or high vehicle speeds or volume. In such cases, well-trained adult crossing guards are a highly-effective traffic control measure to help children cross streets in school zones. Pedestrian overpasses or underpasses have been used successfully where children must cross freeways or wide streets with high traffic speeds, but are a last resort because of their high cost (ITE 1998; ITE 1993a).

The timing of pedestrian signals is an important aspect of pedestrian safety, since an unduly short clearance period (flashing "Don't Walk") will catch children remaining in the crosswalk on green. Several relatively recent improvements in the timing of crosswalks may help reduce child pedestrian injuries. A "scramble" timing signal stops motor vehicle traffic in all directions simultaneously while allowing pedestrians to cross in any possible direction. These systems have reduced pedestrian crash risk by half at downtown locations with high pedestrian activity and low vehicle volumes (Zegeer, Opiela, Cynecki 1982).

Young children may not be readily visible to drivers from a distance, and children of many ages preparing to cross may not activate standard push-button devices to change the pedestrian signal from DON'T WALK to WALK. Accordingly, new "intelligent" pedestrian detectors have been developed. Beams of microwave or infrared frequency detect a pedestrian standing adjacent to a crosswalk, activate the red light, and begin the WALK signal. Other detectors can be placed to extend the crossing time for slower pedestrians, including children. Recent studies suggest that such devices reduce crossing violations by pedestrians and could reduce pedestrian conflicts with motor vehicles (Hughes et al. 2000).

2. Sidewalks

Placement and good maintenance of sidewalks and walkways are important in neighborhoods and along collector and arterial roads where children walk. Sidewalks should connect residential areas with parks, schools, and commercial areas (ITE 1998; ITE 1993a).

A good example is Grandview Drive in University Place, WA (Figure 4.1). There, a residential street had a school at each end of the project area, with no sidewalks or other pedestrian amenities. The city intervened by building a roundabout at a busy intersection and adjacent to each school, narrowing the road, and adding sidewalks, street trees, curbs and gutters, bike lanes, and landscaped medians. Besides enhancing safety, this provided a more attractive, pedestrian-oriented atmosphere. The project resulted in a reduction in speed by 5 m.p.h, and changed the community's attitudes about traffic calming and pedestrian improvements.

Figure 4.1: The addition of bicycle lanes and sidewalks create space for pedestrians while medians and landscaping narrow the street width and slow traffic.

3. Placement of Bus Stops

City transit bus stops should be placed on the far side, rather than the near side of intersections so that pedestrians can be seen easier by motorists (ITE 1993a). Likewise, sites for school bus stops should also be carefully selected to avoid heavy traffic areas or high-speed intersections.

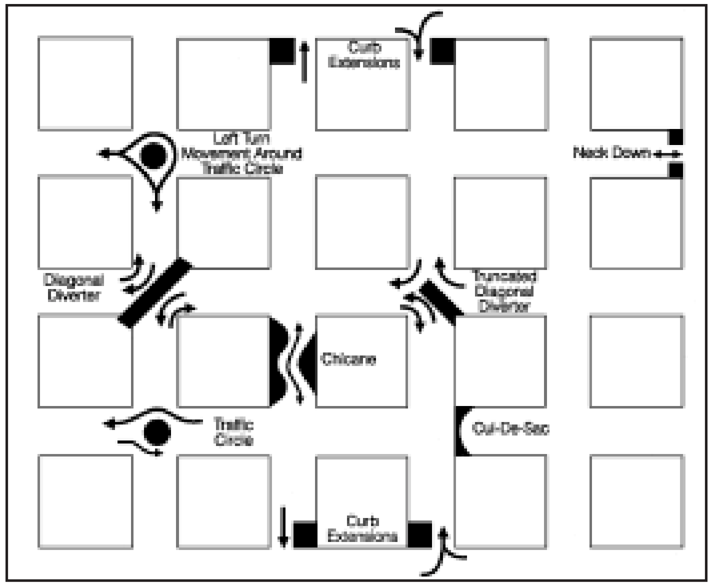


Figure 4.2: Some engineering methods used for traffic calming to promote pedestrian safety. See Appendix B (glossary) for details.

4. Traffic Calming Measures

Various traffic calming measures (Figure 4.2) can slow vehicles and reduce cut-through traffic on residential streets. This requires proper planning of traffic flow on adjacent streets as well, unless such traffic is displaced a block or two away. Traffic calming measures include street narrowing (e.g., curb extensions), speed humps, and partial or full street closures (ITE 1998; ITE 1993b). At busy intersections, several measures can be combined, including building tighter turning radii to reduce speeds of right-turn vehicles and shorten pedestrian crossing distances. In a Danish study by Herrstedt (1992), such management of major thoroughfares successfully reduced speeds by about 6 m.p.h., and increased the number of pedestrians and bicyclists along these streets by up to 45%.

Two examples help illustrate the value of traffic calming. On Milvia Street (dubbed "Slow Street") in Berkeley, CA (Figure 4.3), traffic calming was created using chicanes, speed humps, and curb extensions. This is a residential street, near several daycare centers, a preschool, two elementary schools, a junior high school and a city park nearby. Stakeholders living in the mid-1980s were concerned about the large number of motor vehicle crashes occurring, and particularly when plans were developed to add an office building there. Residents worked with city officials and an office developer to fund and design a slower street. Curb extensions and mid-block planters were installed to create curvature in the street, and one or two speed humps were placed each block over a six-block section. As a result, the street operates at slower speeds and now attracts much pedestrian and bicycle traffic.

Figure 4.3: This chicane of staggered landscaping on both sides of the street creates curves that encourage drivers to slow down.

In another example, Berkshire Street in Cambridge, MA (Figure 4.4) traverses through a mixed-use residential and commercial neighborhood that includes a school, library, and playing field. Many children and other pedestrians cross this daily, but it was also a cut-through route, and many motorists drove at high speeds and ignored stop signs. As a result, several pedestrians were injured in collisions and one died. Consequently, several traffic-calming treatments were implemented, including a raised crosswalk, raised intersections, curb extensions, and a set of mid-block chicanes (tight curves). On nearby streets, chokers and raised intersections were installed to slow vehicles and discourage cut-through traffic from being displaced there. These traffic-calming measures were very effective. Before the project began, only 41% of vehicles traveled on Berkshire Street at or below the posted speed limit of (25 m.p.h.), compared with 95% afterwards. Besides improving safety, these structural changes improved the entire atmosphere of the street, making it more livable and pedestrian-friendly.

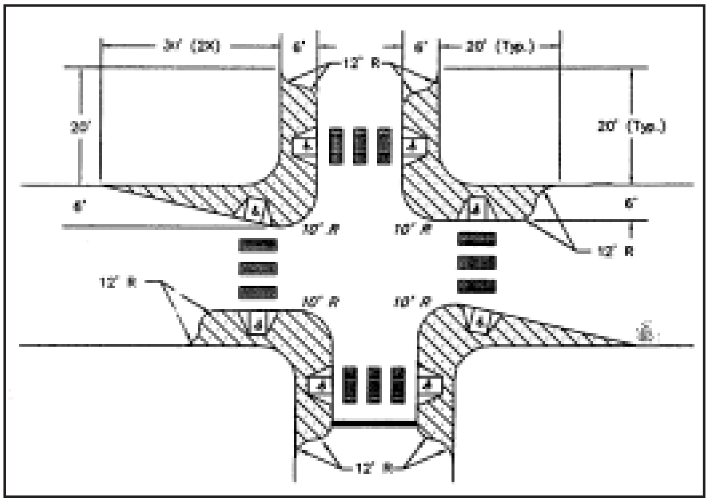


Figure 4.4: This set of chokers in Cambridge, MA narrows the street width which shortens the distance pedestrians have to cross, eliminates illegal parking at the intersection, tightens the turning radii, and slows traffic, all without eliminating any lanes.

5. Median Treatments

A raised median greatly simplifies street crossing by breaking one excessively large step into two smaller parts. That way, the pedestrian needs to judge vehicle speeds and distances in one direction only, rather than two or more, when selecting a safe gap in which to cross (ITE 1998). This is particularly important for mid-block crossing.

6. Other Road Improvements

These include building pedestrian malls and multi-use paths away from traffic, removing sight line obstructions such as prohibiting parking of cars near intersections, providing safe walking areas in work zones, and improving lighting on neighborhood streets.

A special example of a road treatment is the "Woonerf," or "living street." This is a road made sufficiently narrow throughout its course that, even without sidewalks, allows pedestrians, bicyclists, and motor vehicles to travel compatibly. In essence, the speed of motor vehicles is drastically reduced so that it is similar to the speed of foot traffic or bicycles. These are popular in the Netherlands where bicycles are an important mode of daily transportation.

Wall Street in Asheville, NC (Figure 4.5) was originally an alley that ran behind downtown businesses. In the 1940s, the alley was opened to traffic, but its narrow curved street design slowed vehicle speeds considerably. Over time, several businesses opened with their storefronts facing the alley, and Wall Street became an underground arts district. In the 1970s, the street was redeveloped, changing its character into a tourist destination with better pedestrian amenities, retail stores, restaurants, a climbing wall, and a church. The road surface was repaved using cobblestone-looking material. Rather than raising a sidewalk, all pavement is “at grade” (the same level), where bollards and lamp posts separate a strip on both sides of the street from vehicles. At the request of local merchants, parking was added to one side of the street. This left room for only one-way travel, and at very slow speeds. Today, Wall Street is a popular route that attracts many pedestrians, most of whom walk in the street.

Figure 4.5: The bollards, trees, and cobblestones on Wall Street in Asheville, NC make it clear that this space is to be shared by pedestrians and vehicles, as in a European “woonerf.”

Key Barriers

1. Lack of Awareness of These Engineering Solutions

Until recently, transportation engineering practices in many parts of the United States gave only limited consideration to the needs of pedestrians. Historically, course work required by university engineering and planning departments included little or no information about highway safety, pedestrian, or bicycling issues. Although this situation gradually improved in the 1990s, there is still a need to share successes and failures in pedestrian safety throughout the nation. Engineers and planners are often unaware of pedestrian facilities established in other cities or successes achieved by other agencies.

2. Lack of Evaluation

Not enough research exists concerning the effectiveness of pedestrian facilities under various situations. With only a few exceptions, little information is available concerning the relative pedestrian safety benefits of signs, signal innovations, or other features. Consequently, safety engineers and planners designing a new road must select from a group of road treatment options that are often based on very little conclusive evaluation research. Such research, although sorely needed, is costly and requires specialized technical knowledge.

3. Lack of Coordination

Local and state engineers have not successfully coordinated their efforts with planners, educators, law enforcement agencies, and citizens to provide for the safety needs of child pedestrians in their city or jurisdiction. Solving a walk-to-school safety problem requires involvement by school district officials and PTA members to advocate for pedestrian safety education, adult crossing guards, law enforcement personnel to monitor vehicle speeds and red light compliance near schools, and local safety engineers to provide sidewalks, school warning signs and markings, and other measures. Parents and citizens need to work with school and local government officials to propose and help select the best possible solutions.

4. Inadequate Funding

Inadequate funding for pedestrian improvements and safety research is a serious barrier. Careful planning and design of pedestrian facilities does no good without the financial resources and will to implement such plans. Funding for needed pedestrian facilities has been inadequate at the local, state, and federal levels. Recent appropriations by the United States Congress allow, but do not mandate states to use federal transportation funds for pedestrian improvements. Instead, state Departments of Transportation can elect to use these funds in other ways, including building roads. Pedestrian safety research at the federal level is also grossly insufficient to develop and evaluate new and existing types of facilities and devices that assist pedestrians.

5. Low-Priority Mode of Transportation

Many state and local government officials place a low priority on walking as a mode of transportation. This is reflected in the design and building of streets and highways as well as neighborhoods and cities.

Recommendations

1. Conduct Research

Further research should be conducted to determine the effectiveness of various pedestrian facilities and traffic calming measures in a variety of situations (Zegeer 1991). The Federal Highway Administration is producing a manual entitled "Pedestrian Facilities User Guide: Providing Safety and Mobility" to describe 48 types of engineering treatments, including types of traffic calming measures, pedestrian signs, signals, and many others. Research is needed to evaluate the effectiveness of these various road treatments, beginning with pedestrian and traffic calming innovations already built. Four road treatments are in urgent need of further evaluation: (1) crosswalks with flashing lights (now existing in California); (2) illuminated "CROSSWALK" signs placed above the crosswalk to identify it to the motorist (existing in Seattle,WA and Clearwater, FL); (3) "countdown" signals that indicate the time remaining before the steady DON'T WALK and green vehicle signals are illuminated (existing in Arlington, VA); and (4) infrared and microwave detectors that replace the need for pedestrian push buttons by automatically detecting pedestrians waiting to cross the street and initiating the WALK signal (existing in Los Angeles, CA). Results of such evaluations should be quickly and widely distributed to state and local transportation agencies.

2. Improve Guidelines Used by Engineers and Planners

Published guidelines do not adequately address pedestrian needs, yet are generally adhered to by planners and engineers. Current highway design guidelines encourage or require that new roads be built with wide lanes or other features that enable vehicles to speed through collector and arterial streets to the peril of pedestrians. New residential roads are built according to local guidelines that endorse wide, straight roads, thereby encouraging high vehicle speeds and unwanted cut-through traffic. New pedestrian guidelines, presently being developed by the Transportation Research Board through its National Cooperative Highway Research Program, deserve strong local endorsement.

3. Increase Citizen Participation

Selecting and installing pedestrian improvements requires active citizen participation. “Walkable Communities” workshops have been conducted throughout the United States, bringing together citizens (including school children), government leaders, town planners, and engineers to create a new vision for their community, including formulating plans to redesign their cities and neighborhoods to be safer and more convenient for walking. Such programs have successfully considered the special needs of young children’s safety while walking and should be encouraged since they are critically needed in so many areas of our nation.

4. Promote Pedestrian Awareness at the National Level

The Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), and Centers for Disease Control and Prevention (CDC) should continue to develop programs and produce materials that create awareness of the benefits of walking and the need to make walking safer and more convenient for pedestrians. The central message should be that walking is a critical part of our nation’s transportation system and provides tremendous health benefits. Roadway designs that accommodate children and seniors, the most vulnerable populations, would benefit all ages. Alliances such as the Partnership for a Walkable America should be promoted to bring together those concerned with safety, access, and health. These coalitions, by crossing traditional barriers, allow disparate groups to speak in a single, more powerful voice.

5. Implement the Objectives of the National Bicycling and Walking Study

The two major objectives recommended by the 1994 FHWA study are to double the number of bicycling and walking trips and reduce pedestrian and bicycle crashes by 10 percent (Zegeer et al. 1994). The report presents a plan of action for federal, state, and local entities to meet these two goals by organizing a bicyclist/pedestrian program; designing and constructing needed facilities; promoting bicycling and walking; educating bicyclists, pedestrians, and the public; and enforcing laws and regulations.

6. Provide Professional Training

State and local engineers and planners need current training and education about pedestrian issues. These would likely be most effective if offered to University engineering majors during their senior year and to graduate students in engineering and planning programs. A university training course has been developed by FHWA for this purpose. Next, a curriculum on pedestrian facility design that includes traffic calming should be developed for engineers and planners already in the field.

7. Develop Resource Documents

Documents and other tools are needed to explain traffic calming and other pedestrian safety measures to local engineers and citizens. One such example is "Making Streets that Work" (City of Seattle 1996). This recently developed guide describes various road treatment options, their costs, and other considerations. Computer "expert systems" software is now being developed with some success in developing local road treatments to help pedestrians. Such analytic tools should be expanded in the future to include the results of new research, local success stories, and strategies to increase walking for health and physical activity.

Conclusion

Pedestrian safety in many cities is hindered by the basic lack of sidewalks and other necessary road treatments needed by pedestrians. In addition, large areas of many U.S. cities are not conducive to walking, especially compared with the great cities of Europe. Some road treatments exist that, in theory, should provide more safety for pedestrians, but their effectiveness in this domain has not been tested. Certain types of treatments are appropriate for some types of problems, but not for others. Engineers and engineering students do not have sufficient training in this subject, and some of the necessary curricula and training materials do not exist. Given the potential influence a better road environment has on improving safety, these matters deserve high priority.

Response
Engineering Issues

Michael Cynecki, MSCE

One of the most important items needed to prevent child pedestrian injuries is timely, accurate and complete crash data. These data are simply not available to most communities. Phoenix has 1.2 million people and about 34,000 crashes a year. We have to wait 6 to 9 months before we get computerized crash data back from the state. When we do get it back, it has errors and missing data, which makes it difficult for us to identify high-risk crash locations. Also, it is intersection-based and doesn't offer very good link analysis. For example, you can't pick a section of one street and compare it with another section of that, or any other street.

The second thing we need is more staff in local agencies. I have six people who monitor our 4,000 miles of roads and respond to complaints such as speed limits and parking. That means each person has about 180,000 people to serve.

What kind of problems must we deal with? Indian School Road in Phoenix is a good example of a problem street; one that is distinctly unfriendly to pedestrians. This street has seven moving lanes plus a painted middle lane, creating an 84-foot-wide street. It is an example of a street built to move a tremendous number of vehicles, and for that purpose, it works great. It's a real barrier to the community, though. Installing a crosswalk or a sign will not make this a safe street to cross. In fact, after this street was built, people from the adjacent neighborhoods came out and insisted that their community not get a street like this. Pedestrians simply did not feel comfortable walking next to 35 m.p.h. traffic.

We've tried to make some pedestrian improvements in Phoenix. All new streets have a buffer space between the sidewalk and the street, which makes pedestrians feel better separated from traffic. We've retrofitted older streets for pedestrians, moving sidewalks back away from traffic to make them more friendly. To add shade, we're putting trees on both sides of the sidewalk wherever possible. On some streets, we've taken out a traffic lane and put in a bicycle lane, which also adds a buffer between motor vehicles and pedestrians. All new cross-sections on major streets will have on-street bicycle lanes. About half the major streets built will have median islands to allow for easier street crossings by pedestrians.

One of the biggest concerns is with schools. We know that elementary and middle schools should be located well inside neighborhoods and not on their boundaries as they often are today, where traffic flow is heavy and many children need to cross. We have 334 schools in Phoenix in 31 school districts. When a principal is really pro-active, we have good safety conditions around the school. However, when the principal says, "There is nothing you can do with kids," we have problems. There seems to be a lot of chaos, especially at school arrival and dismissal. Our goal is that no child cross a major street on foot to attend school. Realistically, we would like all children to be able to walk to school; this should be an important consideration when searching for new locations for our schools. Statewide, Arizona does have a 15 m.p.h. school zone speed law that includes placing portable signs in the street during school arrival and dismissal. The school is responsible for hiring and monitoring adult crossing guards for the crosswalk, and we provide some basic training. Putting a pedestrian barrier around walking areas in or near school yards is also important. Overpasses are a last resort.

Although engineers design some great devices, people don't always know how to use them. For example, what does the flashing "WALK" signal mean? What does the flashing "DON'T WALK" signal mean? People ask, "Why don't I see the 'WALK' signal every time I walk across the street?" Sometimes we develop things that we think are brilliant but aren't aware of what they look like to the user. Another example is the pedestrian push-button. Do pedestrians realize that if they don't push the button, they will not get the "WALK" signal, or may not be given enough time to cross the street? We need to develop automatic push-buttons or an automatic detection system for pedestrians. We have it for cars; why not for people?

It's important too that we don't just provide pedestrian improvements to one street in a neighborhood, but instead, develop them area-wide. We need to continue working with neighborhoods to fit their needs in finding the best ways to reduce traffic. There is a relationship between vehicle speeds and risk of injury or fatality. The goal is to get vehicles to drive as slowly as possible. We have installed speed humps in neighborhoods. We need to design streets that will make motorists want to drive slower through neighborhoods without relying on speed humps or other artificial devices.

Open Discussion
Engineering Issues

R. Schieber: *What is the cost of redesigning streets in a typical city? How many of any kind of thing can you do in one year on your budget?*

M. Cynecki: The cost of redesigning streets varies from city to city. Our major street projects generally cost about $2 million per mile on major arterial streets. That can vary greatly based on the amount of right-of-way required and how much land needs to be purchased. Some neighborhood traffic calming projects cost about $50,000 to $60,000 for the device to be put in, but the cost may vary greatly depending especially on the drainage required. For example, you might be able to install a diverter for $20,000 at one location that costs $60,000 somewhere else.

Unidentified: *Do you have any sense of how many degree programs for traffic engineers require a traffic safety course that incorporates pedestrians? How many just offer it as an elective?*

M. Cynecki: There are very few universities that offer a course in traffic safety, much less pedestrian safety. There are a few folks around the country who have developed their own courses; a few professors at maybe two or three universities. Most of the education that engineers or planners get concerning pedestrian safety or designing for pedestrians is on-the-job. I hope that will change.

Unidentified: *To what extent are re-engineering solutions driven by data as opposed to "noise," that is, by advocates or local neighborhoods who are upset with things?*

M. Cynecki: Engineering priorities are pretty much advocate-driven. The engineer who once designed that eight-lane street I mentioned earlier was told at the time to build a street to move cars. That same engineer is now designing roundabouts, and he says he is not going to retire until he gets those roundabouts implemented. Engineers can do some great things, but in the end, we do what we are told by the public and elected officials. The elected officials in turn are basically going to do what they are told by the public. So really, you must have advocates such as neighborhood associations state that they don't want to have these big, wide streets going through their neighborhoods.

Unidentified: *Part of the problem with roadways is they can fall within the jurisdiction of either the city, the state, or the federal government. As a community activist, what guidance can you give us for how to get all three sectors to work together instead of the old bureaucratic response, "It's not my road?"*

M. Cynecki: That's one of the big problems we face. We have seen some jurisdictions where there is a fairly good working relationship among these entities. Some metropolitan planning organizations, like the one in Madison, WI, are working with their cities and other states. One barrier we face is getting people to talk and work together, and to really focus on the needs of pedestrians.

S. Havlick: *Can you give us some specific examples of how one might reconcile the potential backlash from SUV fanatics as a result of traffic calming measures installed and other social and engineering tools that have been proposed this morning? At some point, one might anticipate that we could become so successful at traffic calming that it might create an adverse response from motorists. This would be an unintended consequence. It might be less likely to occur in Chapel Hill than in Phoenix, but I'm curious about how you might deal with such negative responses from motorists who don't understand your message.*

M. Cynecki: How do we respond to the people who normally cut through? We get a lot of complaints from those people, but we simply don't put as much stock in what they say as the people who live in that neighborhood. For example, we have one street where we converted a four-lane to a three-lane design with bike lanes. As a result, commuters accessing this street as a cut-through route found it to be highly congested, yet the local residents liked it. I think engineers are learning to listen better rather than saying to a community, "Here's what we are going to do, like it or not." We've seen some really good examples of neighbors getting involved in making decisions in Seattle and Portland. These cities have advocate groups at the neighborhood level that come to city officials and their engineers saying, "Here's what we want." Those city officials are listening. That is one of the best situations – engineers working with citizens and not against each other.

T. Miller: *As I look at these things, I worry. I see places where engineers are putting in trees that will get big, possibly endangering drivers who crash. I see brick sidewalks that are prone to becoming tripping hazards and can be very expensive to maintain over time. I see curbs built without any thought given to handicap access. I see no discussion of tripping hazards for pedestrians or icy conditions. I really feel that all the attention is being given to how we make pedestrians interact better with cars, without any thought to the impact on the pedestrian overall or the impact on the car overall.*

M. Cynecki: Anything you put in, you have to maintain. We found out that if you put in bricks, you have to use a concrete base, lest the bricks settle and become an obstacle to pedestrians using wheelchairs. We've had pretty good success with the bricks that we now use, but when we first started, we didn't use a concrete base, and there were a lot of problems. Trees also need to be maintained. When you plant more trees, you have to increase your parks and maintenance staff to make sure the trees don't affect visibility. We use trees with very small caliber trunks, but they do become bushy and need to be maintained to assure adequate visibility and safety.

B. Wilkinson: We need to fundamentally rethink the way we design and manage our transportation system. We really need to focus on the speeds that roads are designed for. My response to the school site issues was to slow the cars down. I don't care what the volume is, they shouldn't be moving more than 25 m.p.h. down those streets. We really need to give a lot more attention to how we manage speed through design and enforcement. We need to set a new direction for the design of streets and highways so that speed is not the top priority of traffic engineers. And, finally, we could go back and completely retro-fit a pedestrian-friendly infrastructure in most communities in the United States for the cost of one or two miles of interstate highway or an interchange. Money is not the issue. It is the commitment of the public agencies and decision-makers to actually create pedestrian-friendly communities.

C. Seiderman: We don't need to wait for crashes to happen to fix our road systems, and we don't need to look for money because it is already there. It isn't that crashes aren't important, but I can probably go to a city and tell you where all the high-crash locations are. We need to look at places that are already listed to be reconstructed for some other reason, such as for regular roadway maintenance, sewer work, or water work. Then we should say, "You are fixing it anyway, just do it better." Just tie pedestrian-friendly measures in. This is something that isn't often thought about. Instead of lobbying for new projects and new money, tie pedestrian-friendly improvements into other projects about to be undertaken.